DARK ENERGY
SURVEY

PreCam Results & Plans

(Version: 9 May 2011)

Douglas L. Tucker
(FNAL)

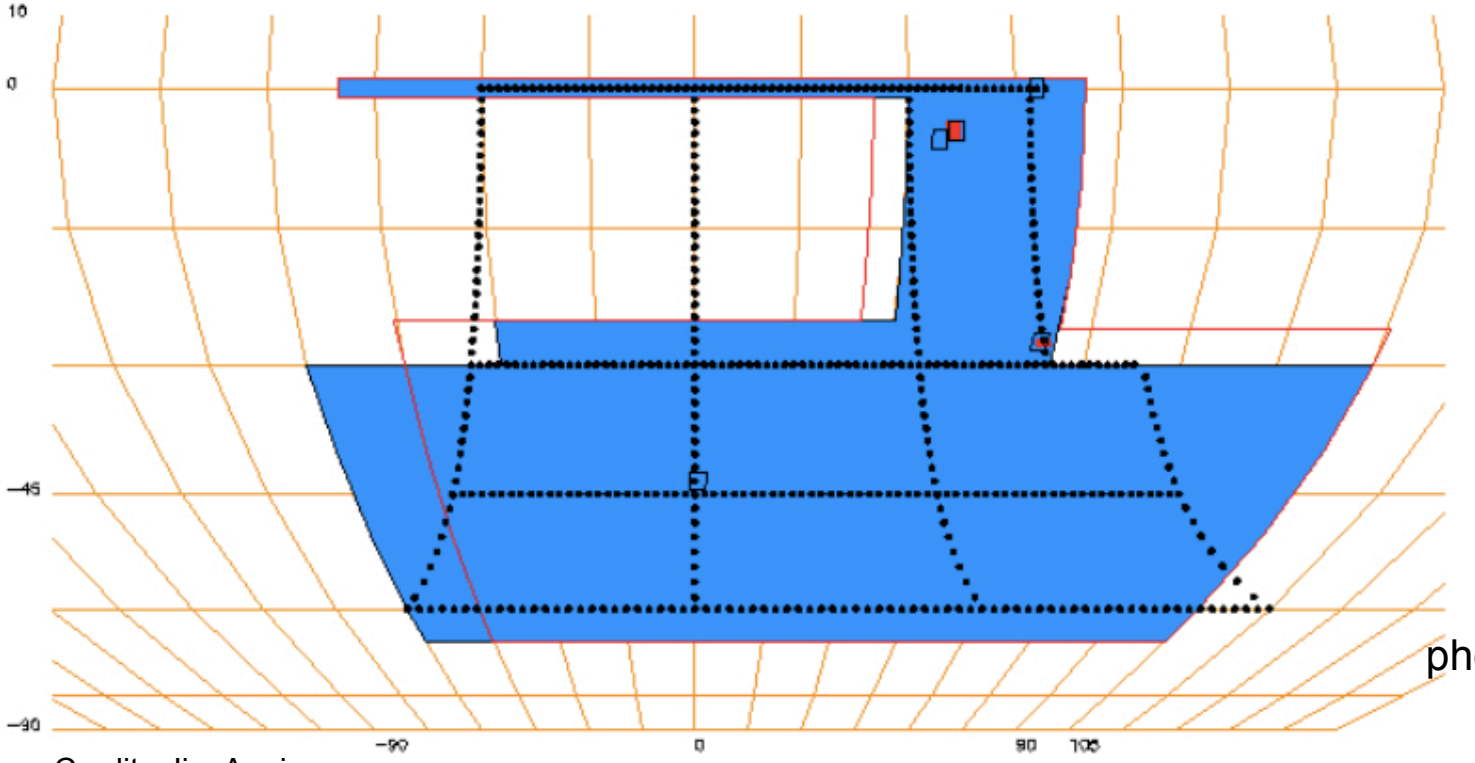
DES Directors' Council Review
10-11 May 2010

The PreCam Survey Strategy as Originally Planned

DARK ENERGY SURVEY

I. Aug 11-31: h/w install. and commiss.; Sept 1-15: on-sky commissioning

II. Sept 15-Sept 27, Nov 16-30, Dec 9-Jan 24 is devoted to observing 30° grid



Credit: Jim Annis

version 5
modified 30° grid
454 hexes

10x in each filter
(~6x under
photometric conditions)

August-September Problems

DARK ENERGY SURVEY

Poorly Manufactured 2ndary Mirror

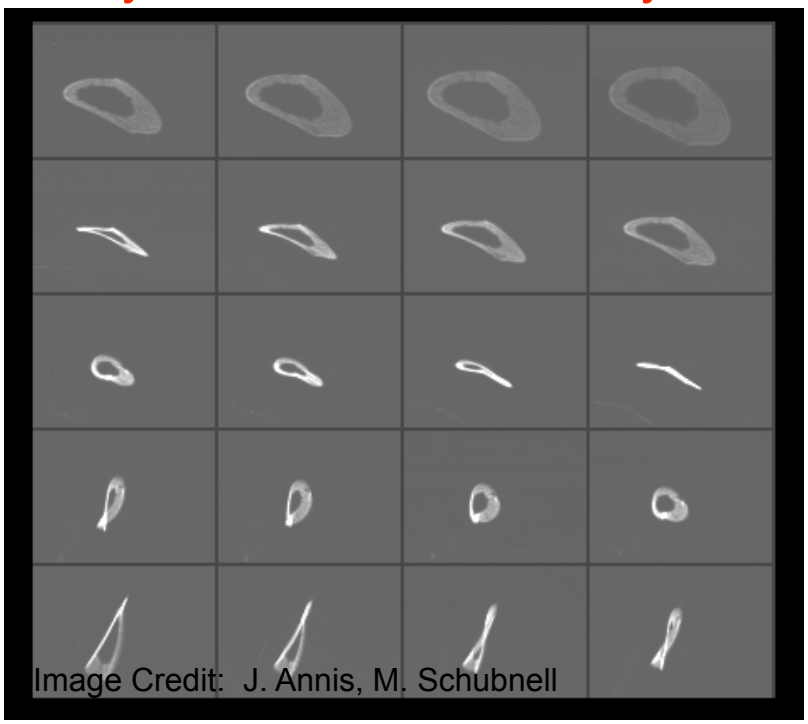


Image Credit: J. Annis, M. Schubnell

Broken Shutter

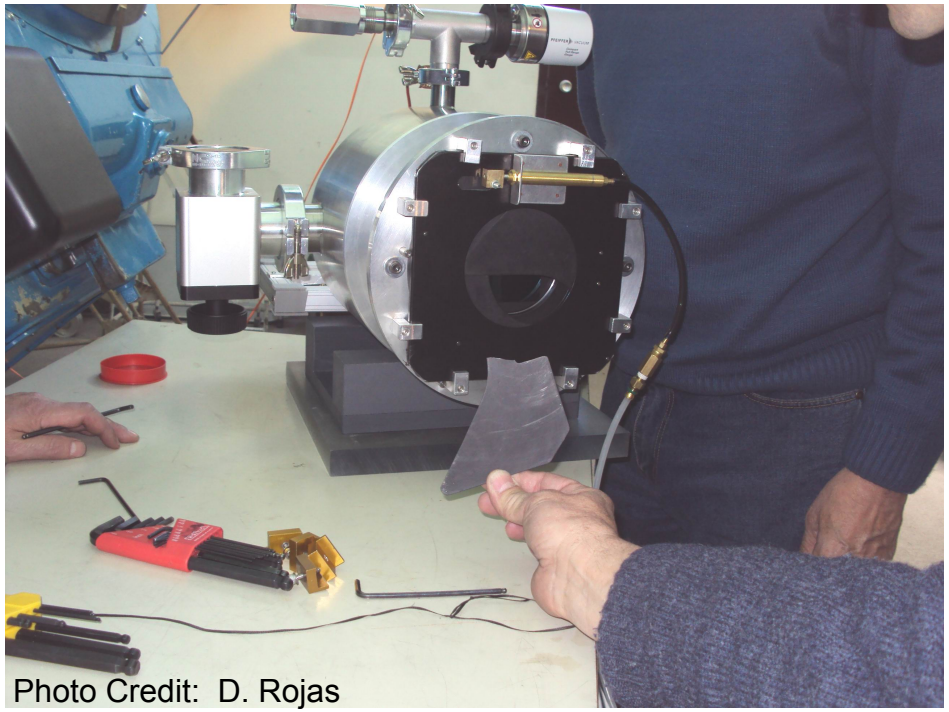


Photo Credit: D. Rojas

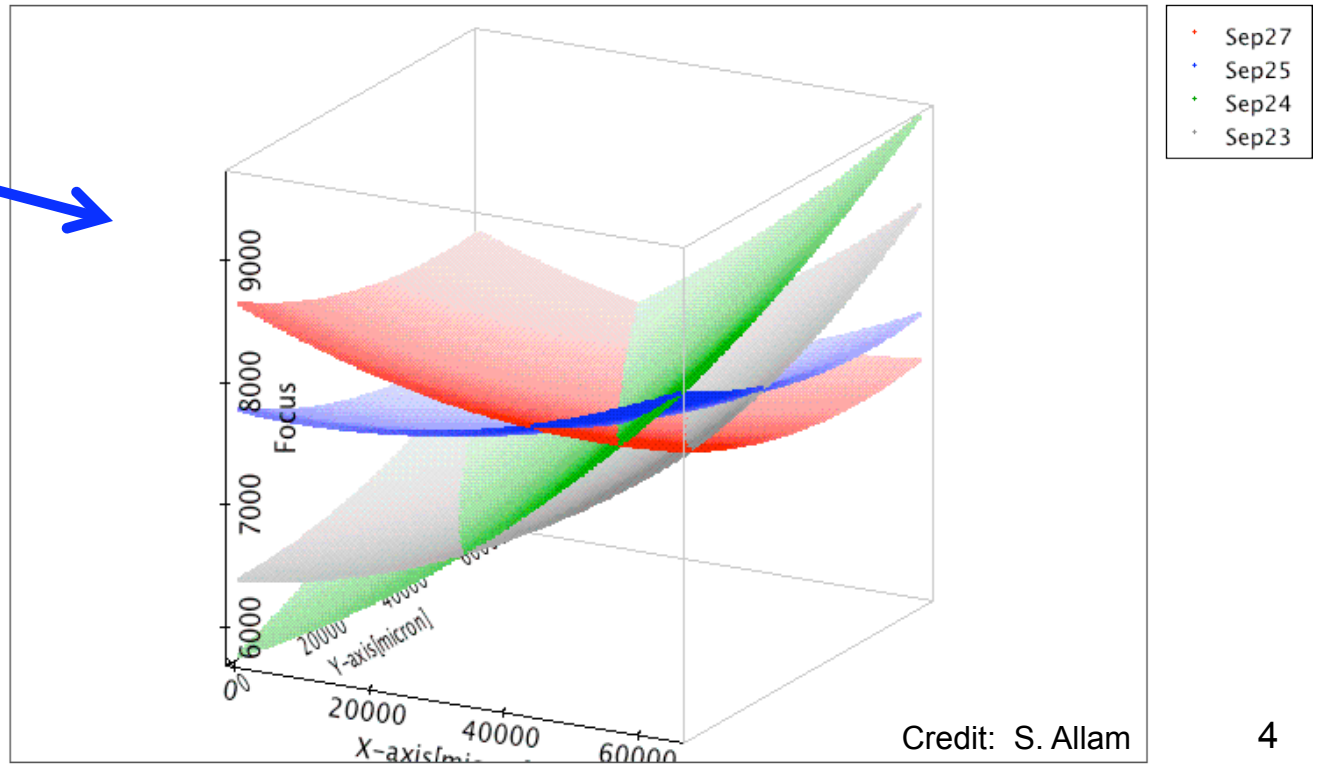
FITS header problems,
(esp. w.r.t. adding RA,DEC from Curtis-Schmidt TCS)

```
SIMPLE  =                    T / conforms to FITS standard
BITPIX  =                   16 / array data type
NAXIS   =                    0 / number of array dimensions
EXTEND  =                    T
…
RA      = '25:0:0.0'         / [HH:mm:ss.ss] RA for center of this detector
DEC     = '91:0:0.0'         / [DD:mm:ss.ss] Dec for center of this detector
…
```

August-September Successes

DARK ENERGY SURVEY

1. Safely shipped PreCam, PreCam computers, PreCam CCDs, and auxiliary equipment to CTIO and mounted on the Curtis-Schmidt (C-S).
2. Hardware upgrades to C-S, including new TAMU dome flat system.
3. Quick Reduce and data transfer installed on PreCam computers
4. Preliminary observing scripts written.
5. Realigned optics with powerful new quantitative technique.
6. Identified problems to be fixed.
7. **PreCam on sky!**
8. **Built successful PreCam team!**



Credit: S. Allam

Final PreCam Survey Strategy

(original, smaller secondary mirror; less time)

DARK ENERGY SURVEY

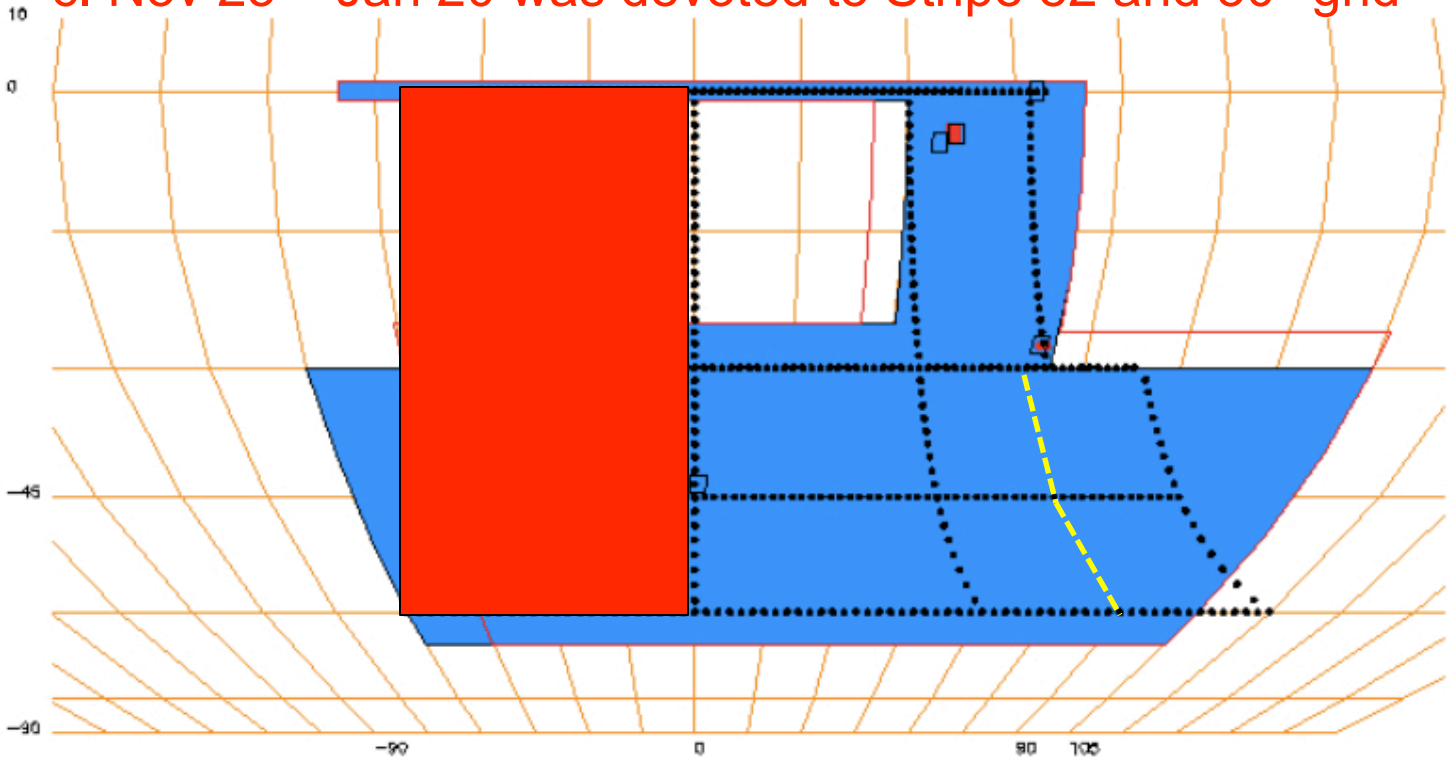
I. Aug 11-31: h/w install. and commiss.; ~~Sept 1-15: on-sky commissioning~~

II. ~~Sept 15-Sept 27, Nov 16-30, Dec 9-Jan 24 is devoted to observing 30° grid~~

Sept 1-27 was devoted on-sky commissioning and debugging of h/w

Nov 16-c. Nov 24 was devoted s/w commissioning and on-sky tests.

c. Nov 25 – Jan 20 was devoted to Stripe 82 and 30° grid



Stripe 82:
10x in *grizy*

30° grid:
6x in *gri*

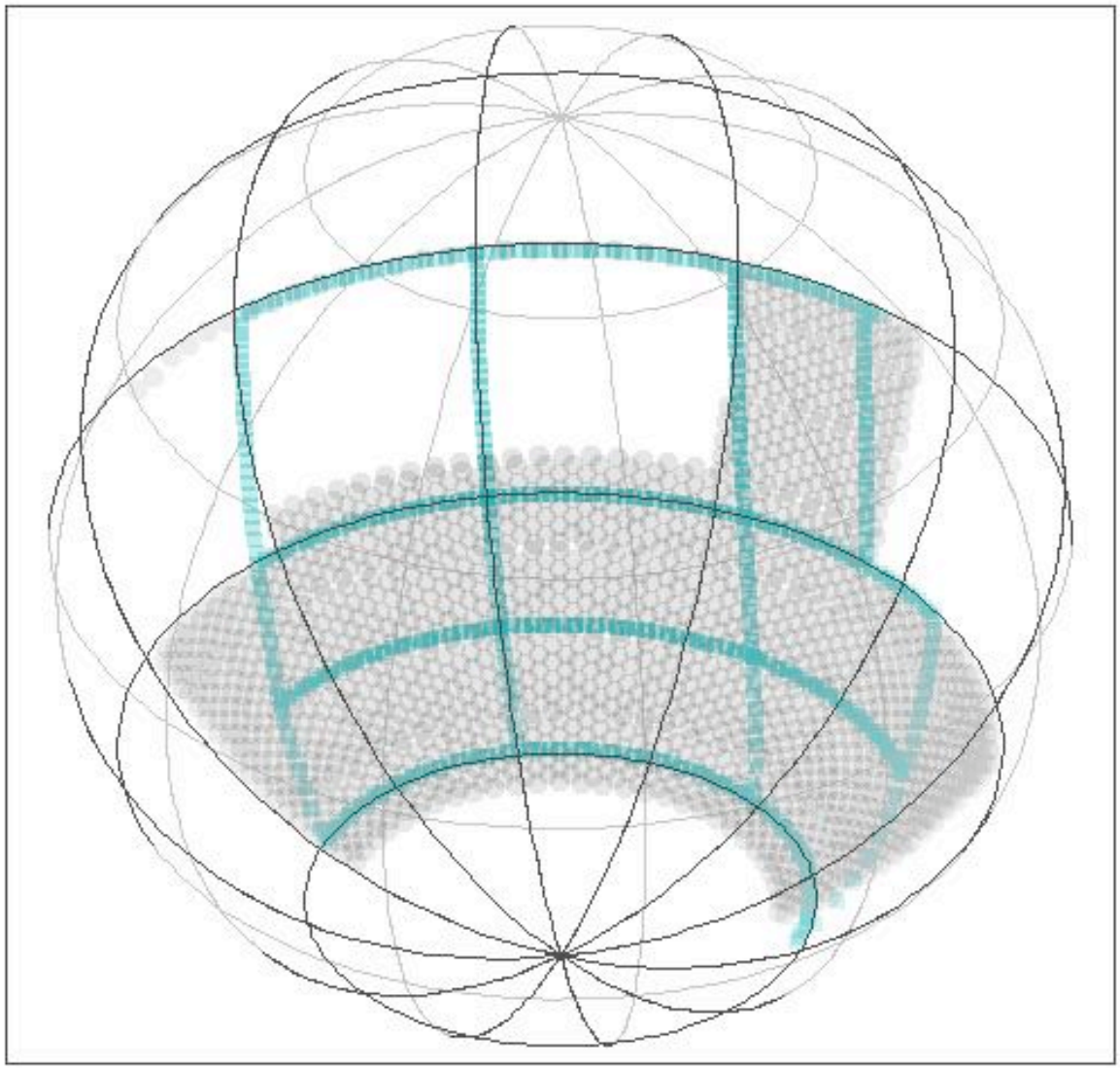
DARK ENERGY SURVEY

Nov-Jan: The Data

- 64 nights allocated (Nov 16-Jan 20 minus Dec 24-25)
  - 1 night lost to weather
  - 2 nights lost to software meltdown on original DAQ computer
  - 2 nights lost to shutter breaking
  - 4 nights devoted to engineering due to shutter-sticking
  - 1 night lost due to venting dewar to ambient atmospheric pressure
  - 1 night lost due to problems with installing new 12-channel DAQ card
  - 2 nights devoted to end-of-run engineering tests
- 51 nights on sky (c. 80% of the 64 nights allocated)
- ~24,000 images

DARK ENERGY SURVEY

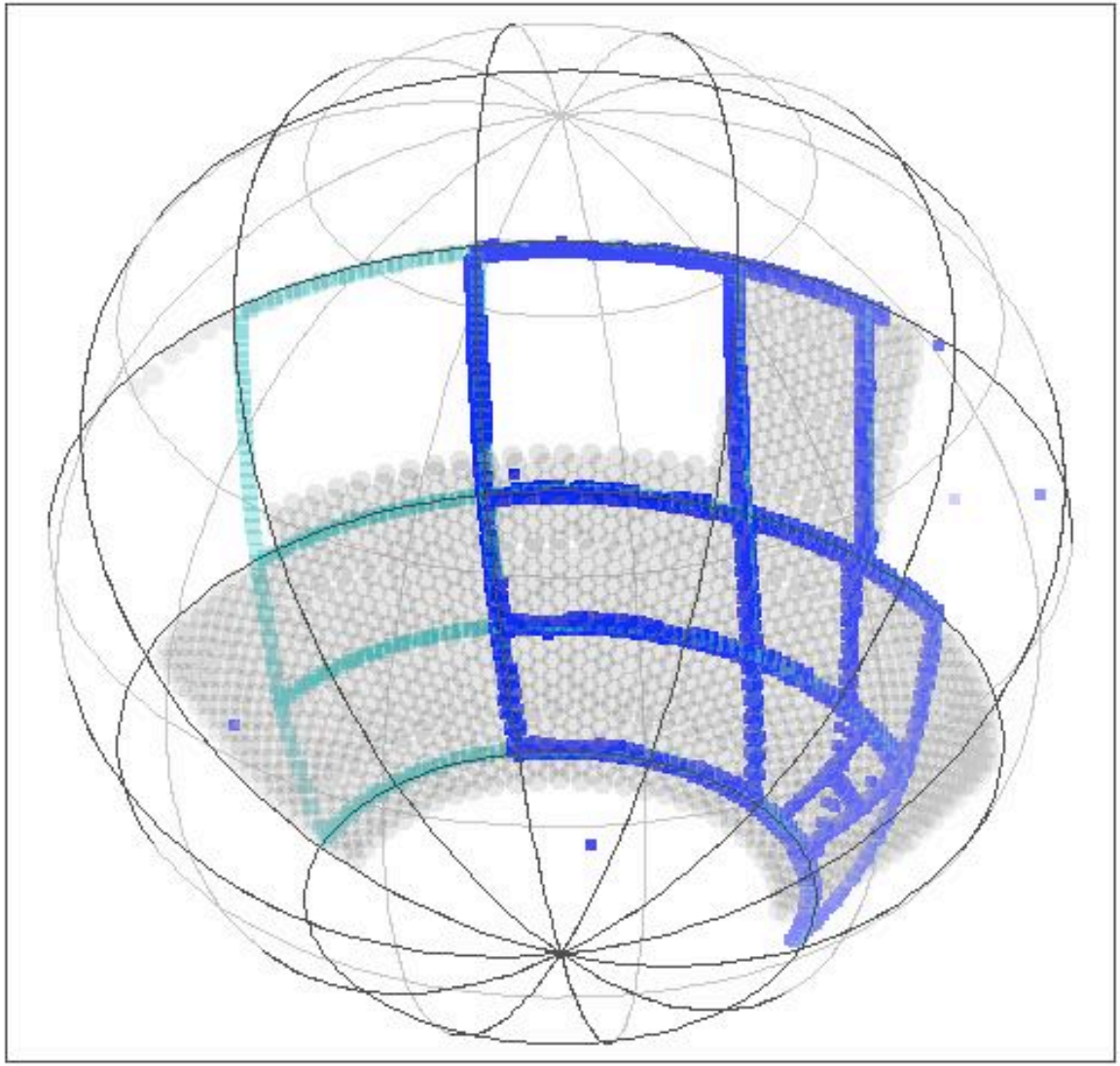
Actual PreCam Coverage as of Jan 20



Originally Planned

Actual PreCam Coverage as of Jan 20

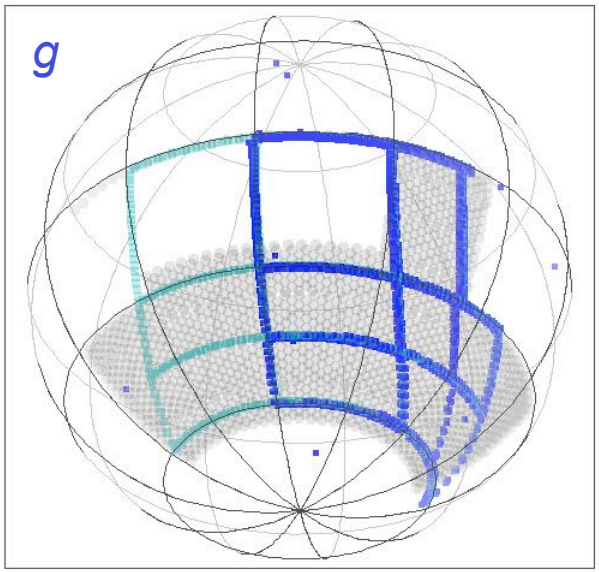
DARK ENERGY SURVEY

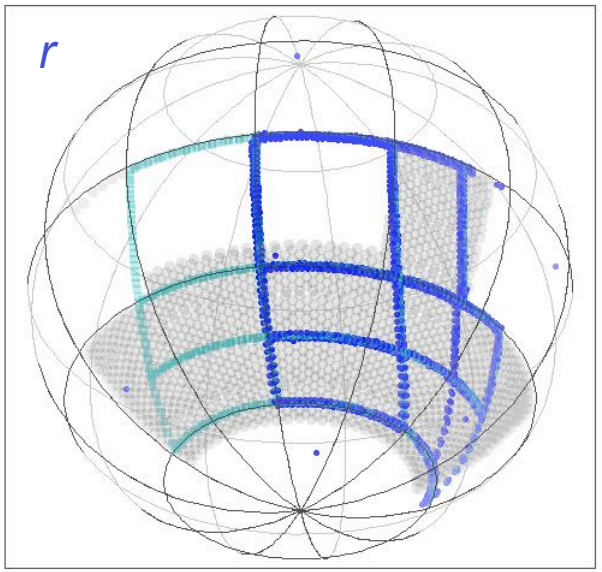


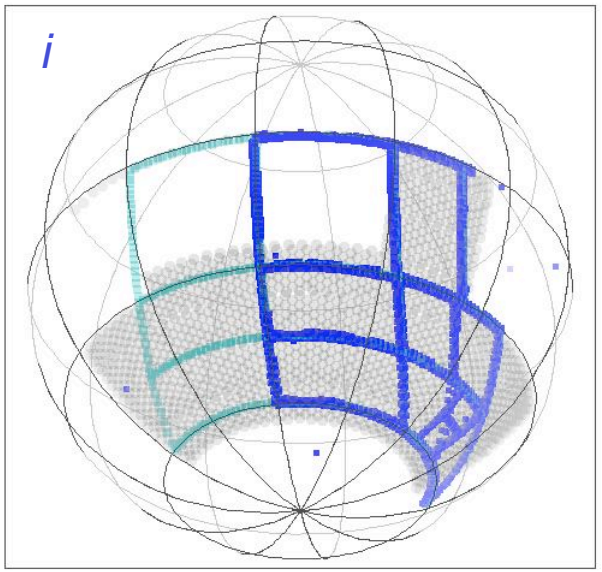
Originally Planned

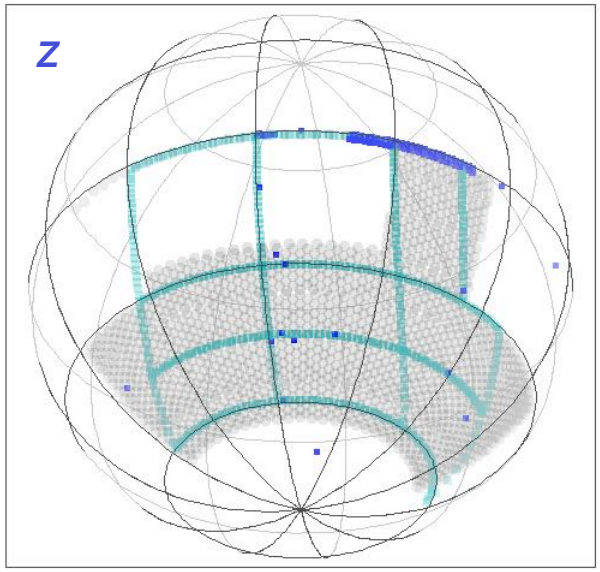
Final (*i*-band)

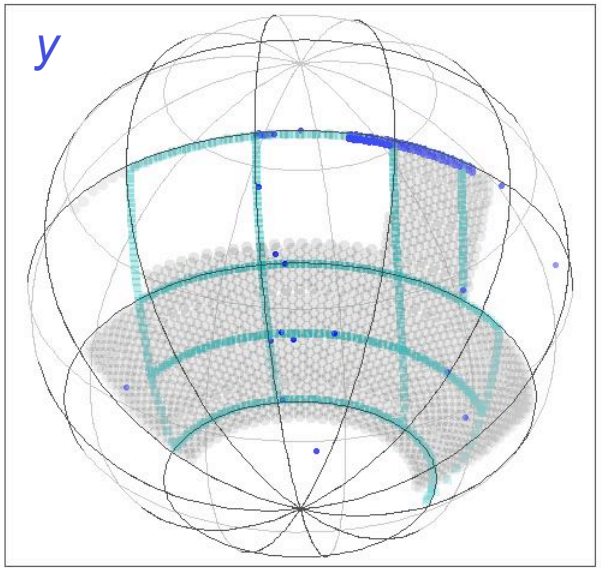
Actual PreCam Coverage as of Jan 20











Actual PreCam Coverage as of ~~Jan 20~~ Jan 12

DARK ENERGY SURVEY

g *r* *i*

Tile 1:

Tile 2:

Tile 3:

Tile 4:

Tile 5:

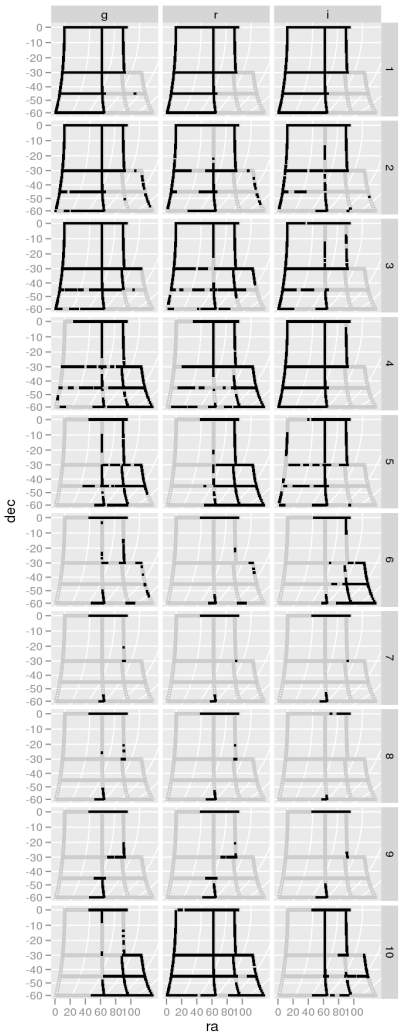
Tile 6:

Tile 7:

Tile 8:

Tile 9:

Tile 10:



- After Jan 12, we pursued a modified tiling strategy, so these exposures do not show up.
- These post-Jan 12 exposures are primarily in the South-East corner of the PreCam grid pattern.

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Data Processing

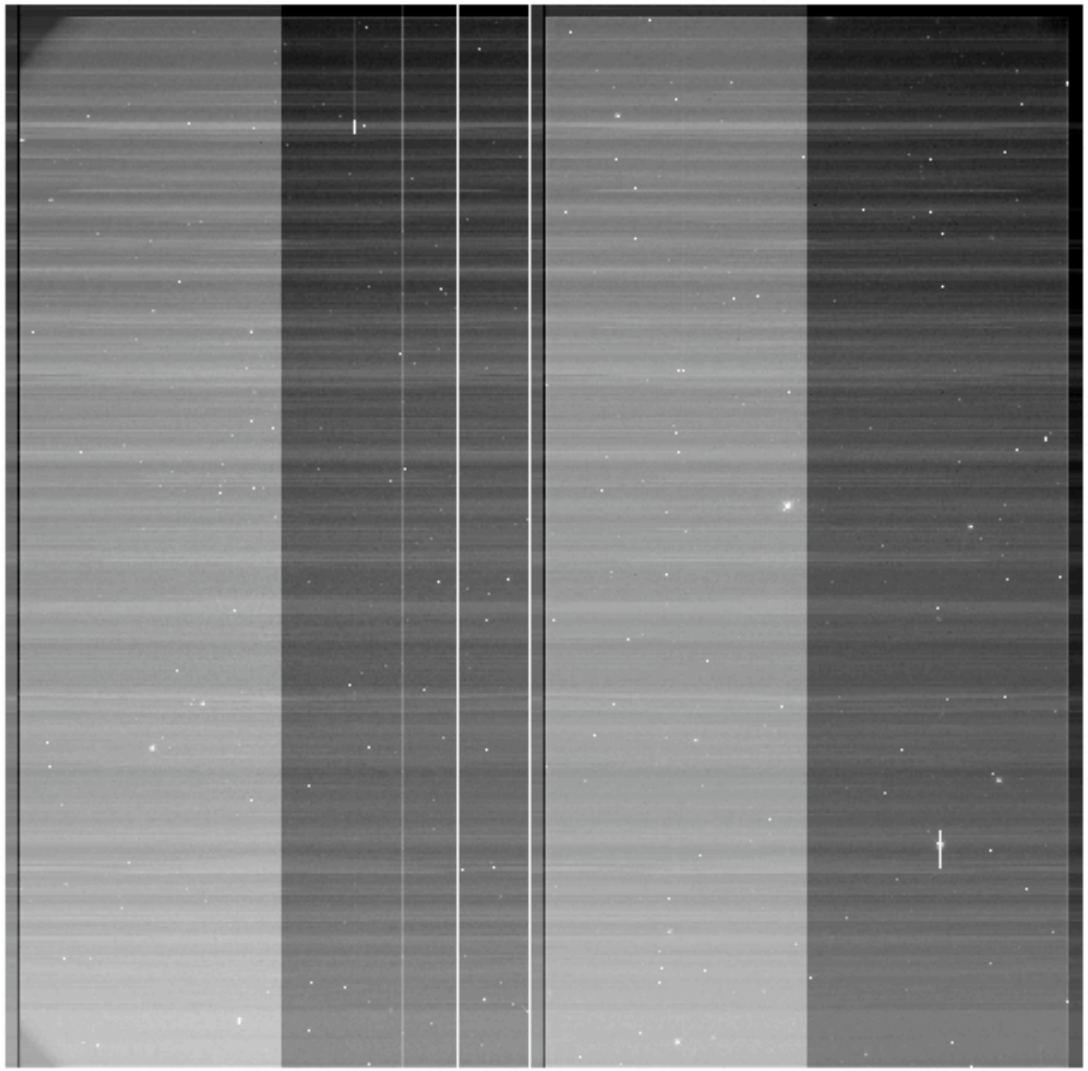
- DES-Brazil Effort
  - The official data processing.
  - Uses a PreCam-specific version of the Quick Reduce Pipeline.
    - Quick Reduce in turn uses the DESDM code.

- FNAL/ANL Effort
  - R&D effort using custom scripts in order to understand the data and obtain some quick results.
  - Provides feedback to the official data processing.

- “Golden Nights”
  - A set of 5 nights with robust FITS headers, no known problems, and target observations in SDSS Stripe 82.
  - Used by both data processing efforts for rapid testing and algorithm development.

DARK ENERGY SURVEY

Results: Horizontal Banding & Streaking



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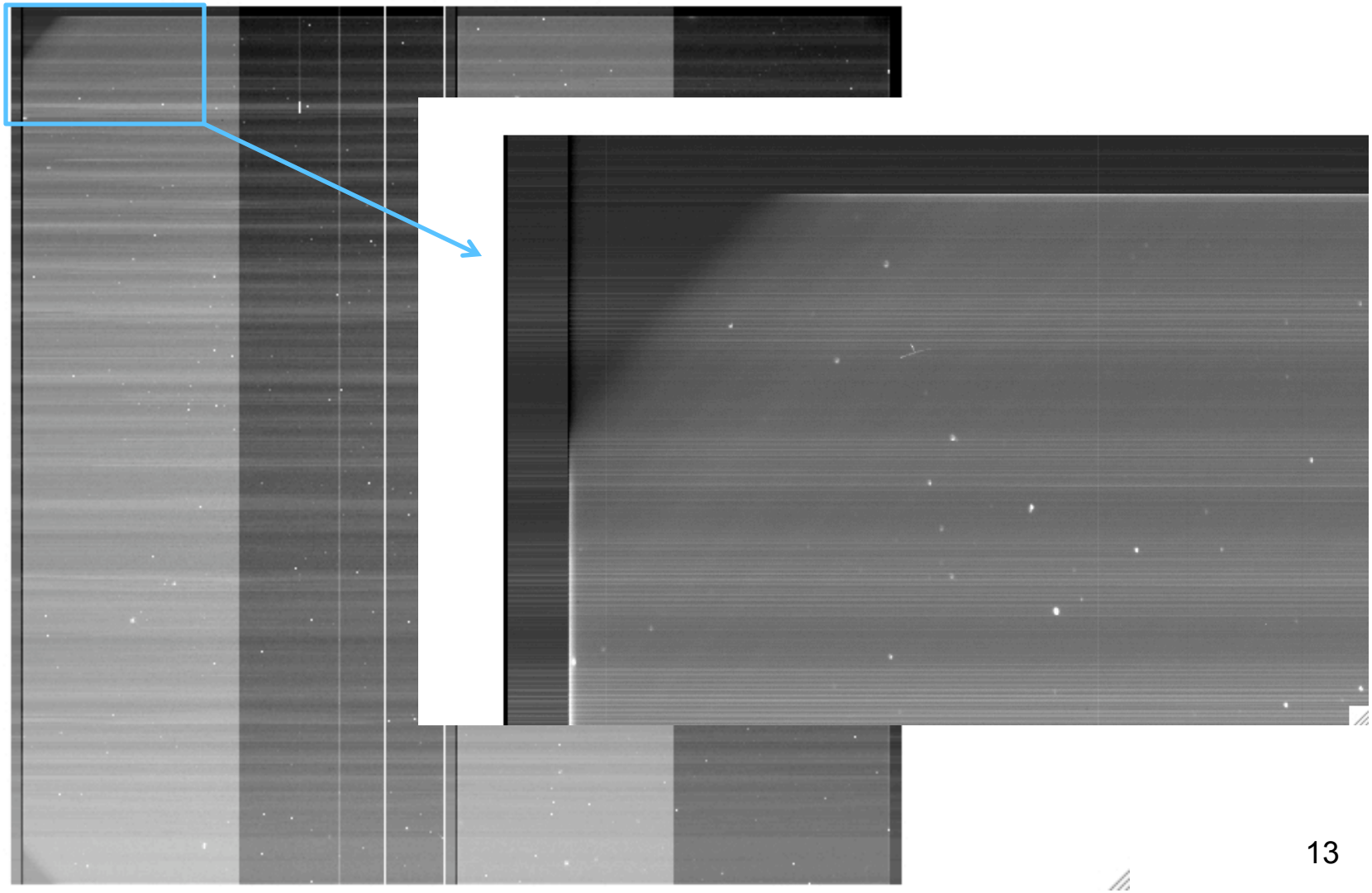
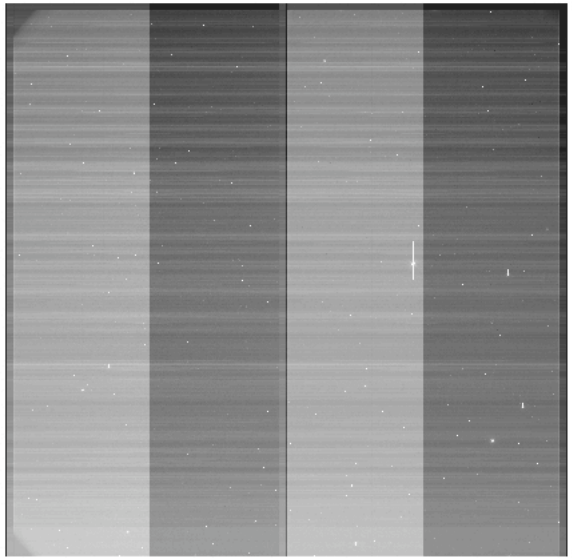


DARK ENERGY SURVEY

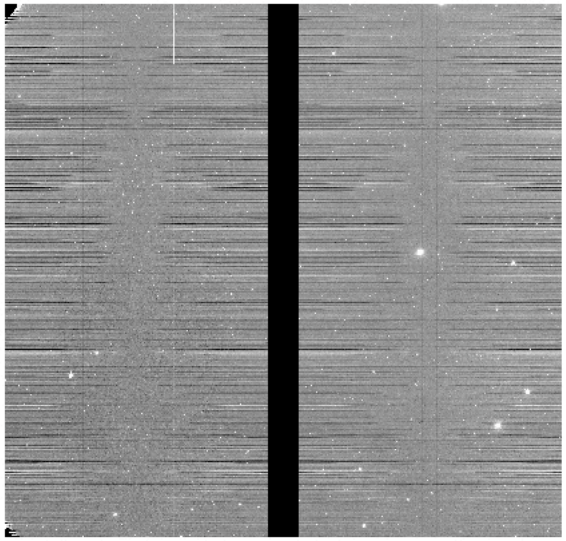
Results: Horizontal Banding & Streaking

A Pretty Bad Case of Banding and Streaking

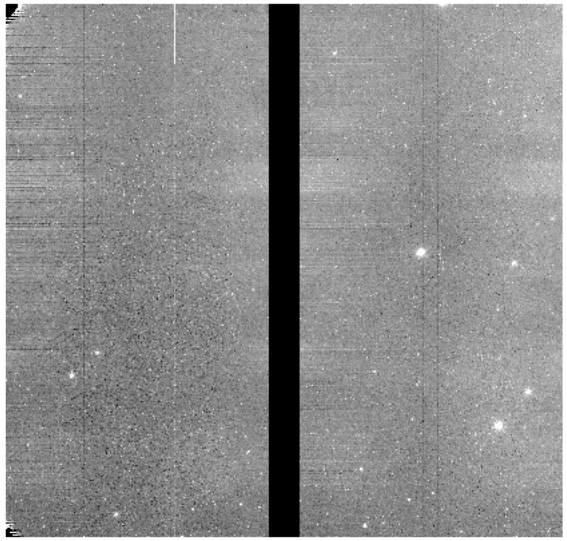
Original Image



After row-by-row overscan subtraction



After horizontal streaking correction



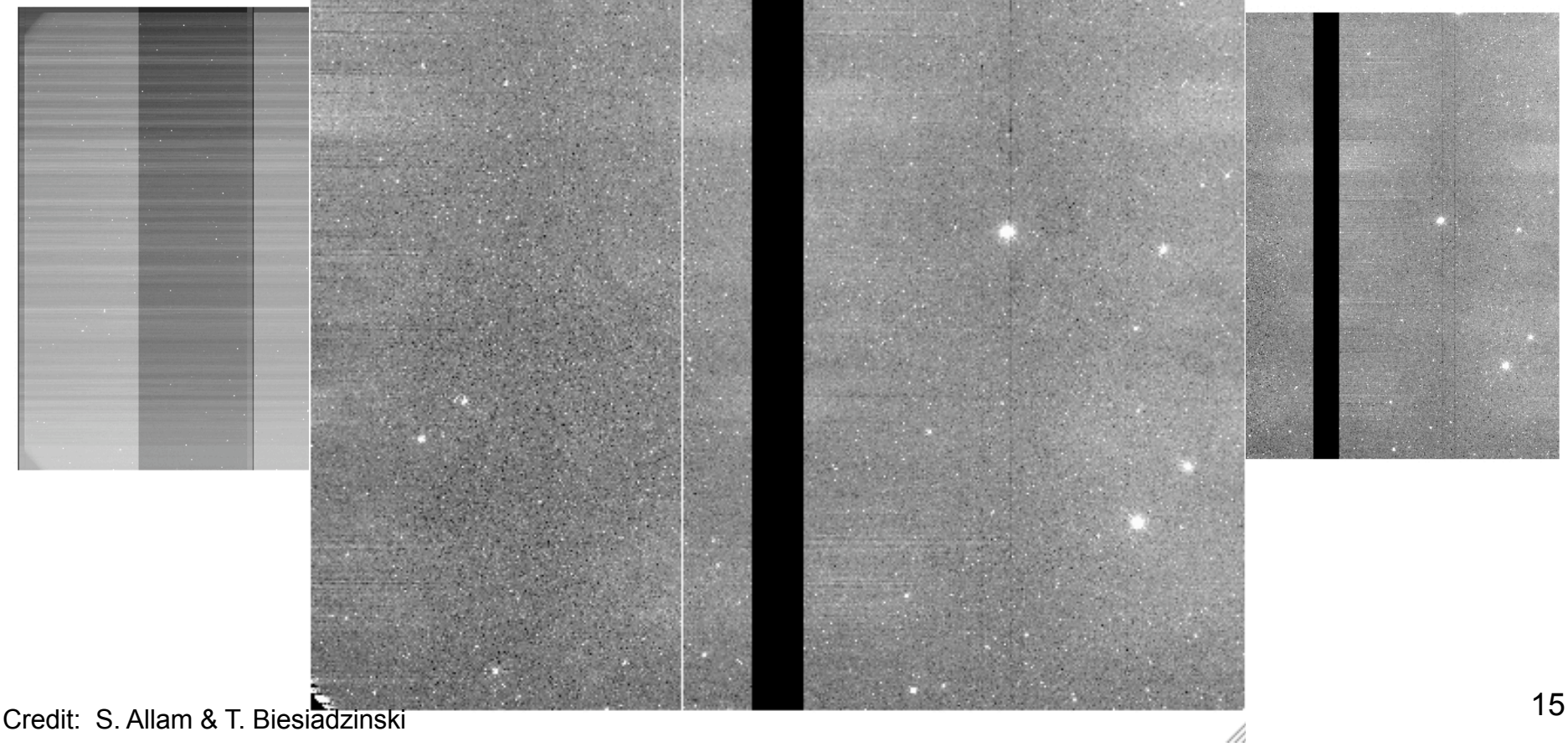
Credit: S. Allam & T. Biesiadzinski

Results:
Horizontal Banding & Streaking

DARK ENERGY SURVEY

Original Im

er horizontal
king correction



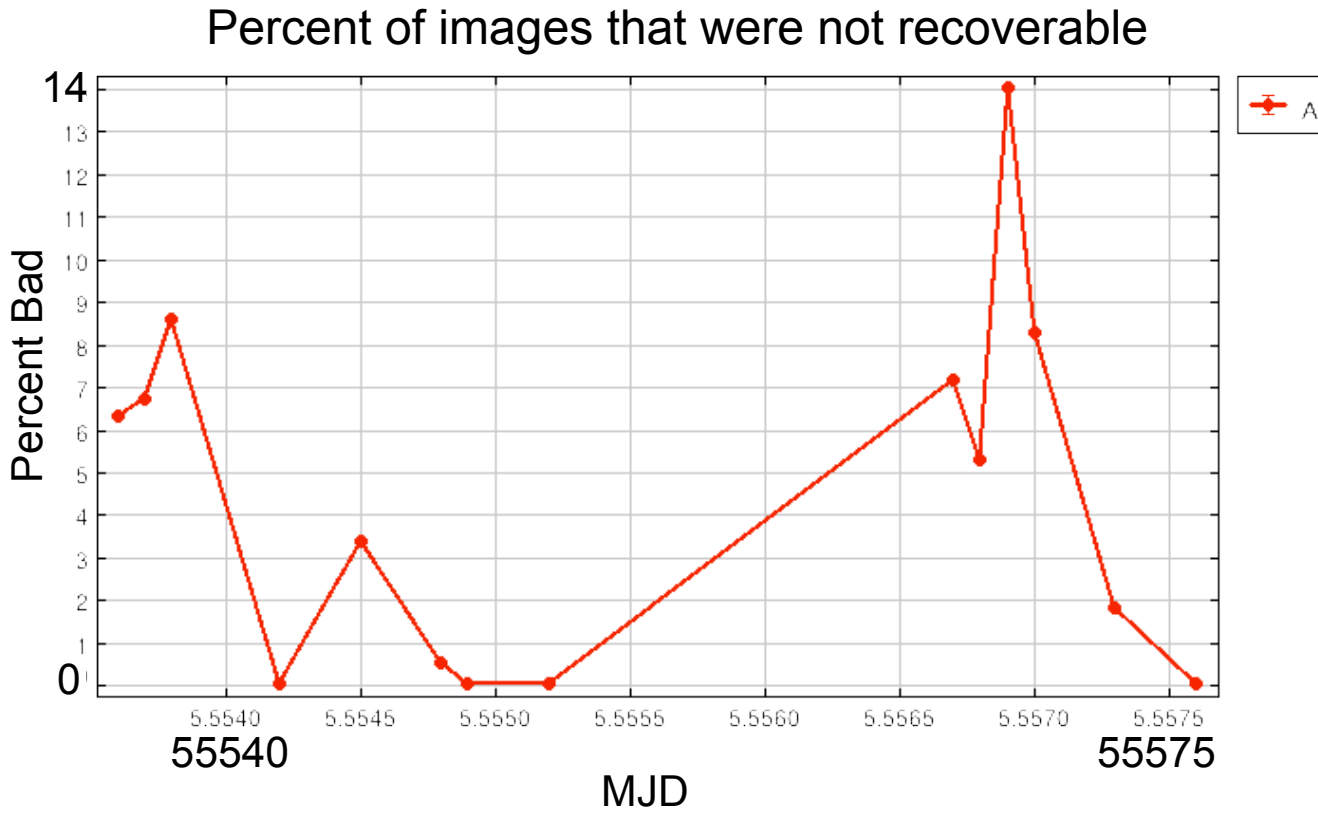
Credit: S. Allam & T. Biesiadzinski

Results: Horizontal Banding & Streaking

DARK ENERGY SURVEY

- Horizontal banding & streaking affect ≈40% of the raw PreCam standard star field and science target images.

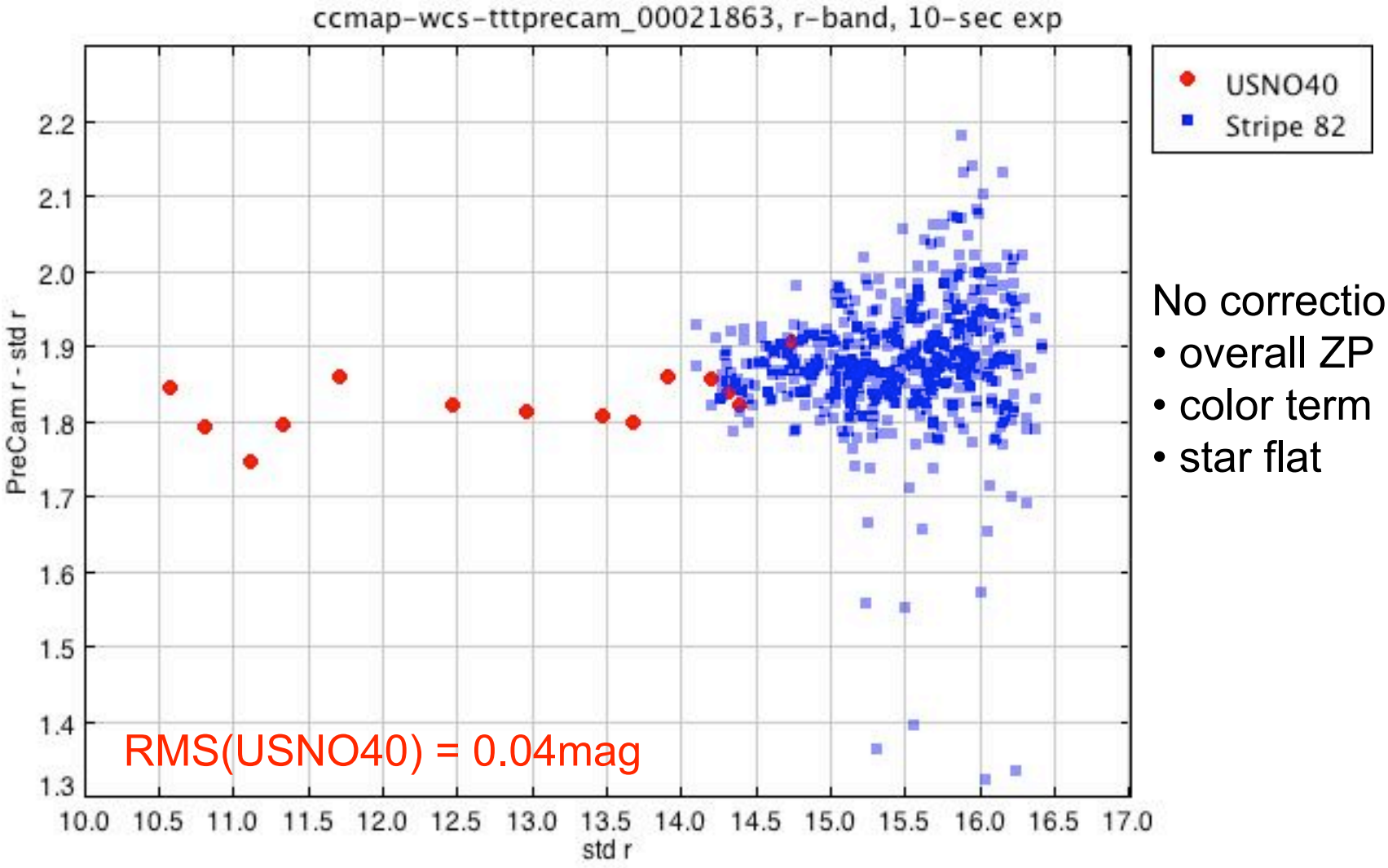
- After correcting, horizontal banding & streaking affect only about 6% of the processed images.



Credit: S. Allam

Results:
Initial Photometry for a Single Image

DARK ENERGY SURVEY



No corrections for:
- overall ZP
- color term
- star flat

Results: Photometry over a Full Night

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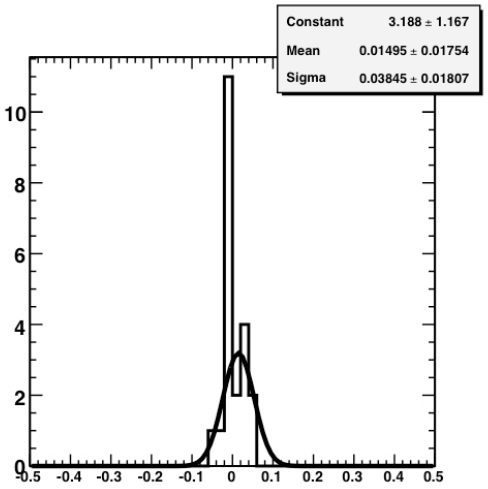
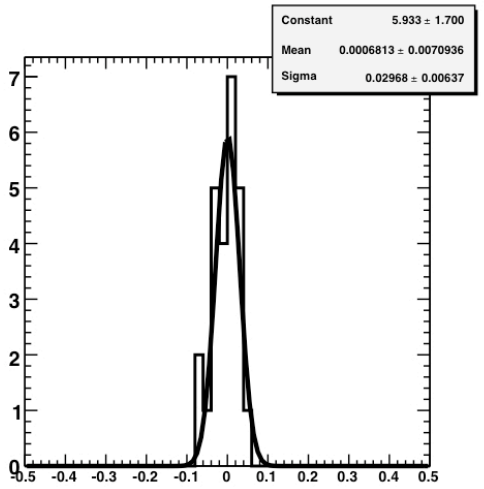
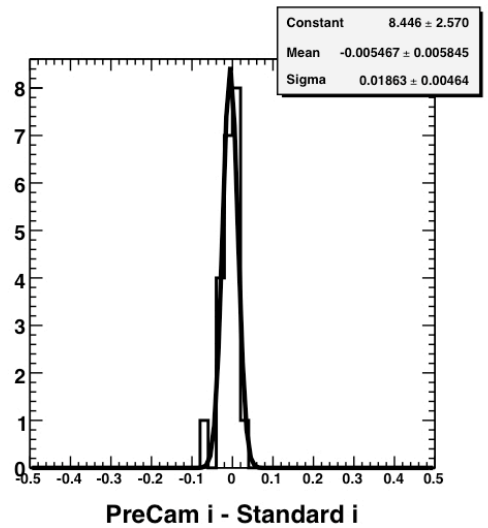
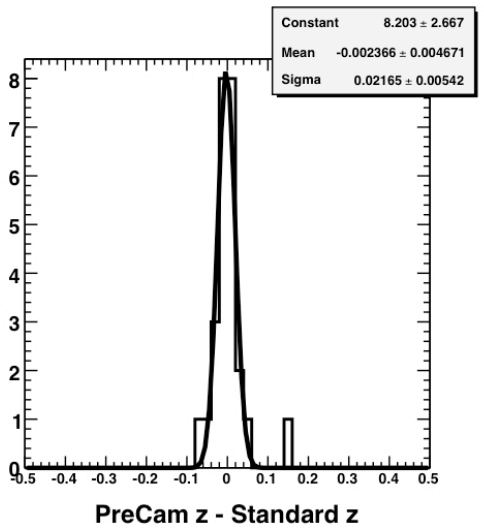
- Night of 13 Jan 2011 UT.
- All data from that night matching the extended list of USNO *u'g'r'i'z'* standards.
- Corrections for overall ZPs and for airmass (using site-average first-order extinction coefficients)
- No correction for color terms.
- RMS = 2-4% (mag < 13.0).









Credit: S. Kuhlmann, H. Spinka

Results:
SDSS-DES Color Terms

DARK EN
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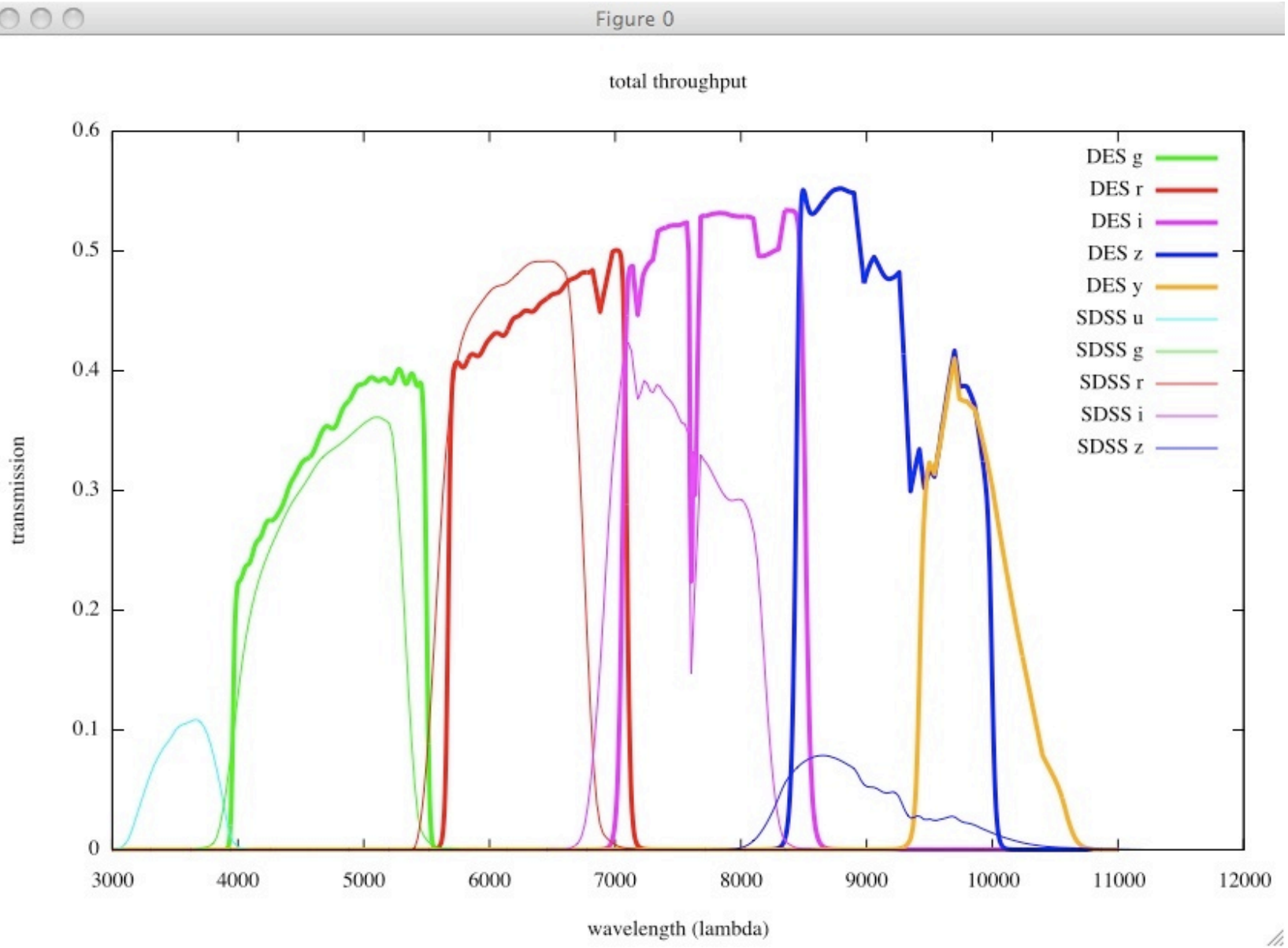
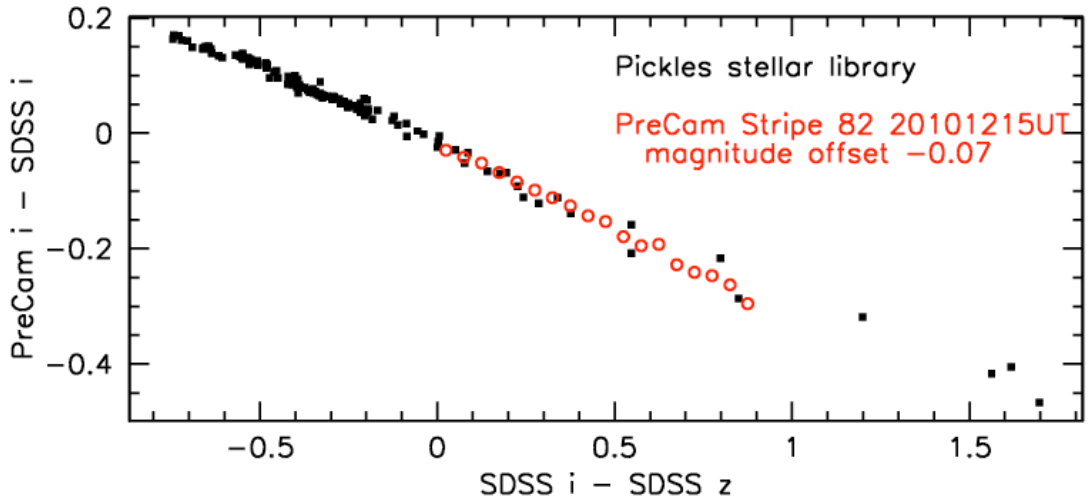


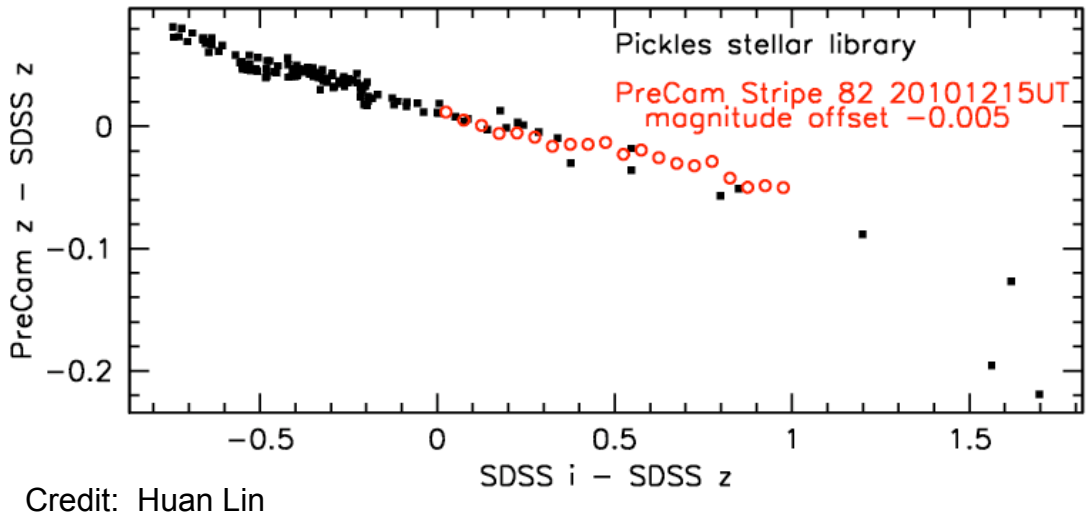
Results: DES-SDSS Color Terms

DARK ENERGY SURVEY

- Synthetic color term relation plotted with (binned) observed color term relation from PreCam for the night of 15 Dec 2011 UT.

- The observations have relatively few blue stars compared with the Pickles stellar library.





Credit: Huan Lin

DARK ENERGY SURVEY

Accomplishments/Lessons Learned Relevant to DES Commissioning

1. Quick Reduce Commissioning & Experience and Dramatic Improvement in the DES-Brazil Portal
   - First use of QR during live observing at CTIO

2. ObsTac Commissioning & Experience
   - Substantially increased efficiency
   - Basic design showed its flexibility
   - Survey Strategy: Full Moon crosses Stripe 82 (affects survey strategy for *izy*)

3. DECam Control System (CompactRIO) Experience
   - 24K shutter exposures with no failures, plus Temp/Vacuum monitoring over 7 months

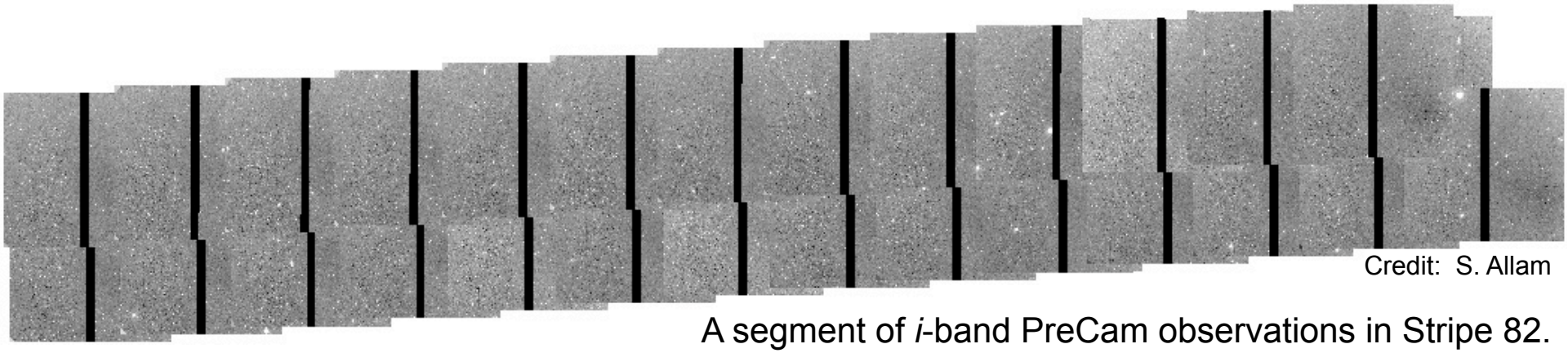
4. "Live-fire" Experience with SISPI and Related Observing Software
   - A special PreCam branch of SISPI

5. Observing run staffing and training
   - 16-hour shifts combined with runs longer than 7 nights can be fatiguing, especially when hardware or software problems arise

Plans

DARK ENERGY SURVEY

1. Determine final detailed plan for official processing.
2. Finish processing data.
3. Analyze data.
4. Determine how much more observing time would be needed to achieve the original PreCam goals (esp. with regards to global relative calibrations of DES), and the consequences of de-scoping if that proves necessary.
5. It is likely that PreCam would need another full season – or two half seasons, since Aug/Sept 2011 might not be available? – to fully achieve its original goals.



Credit: S. Allam

A segment of *i*-band PreCam observations in Stripe 82.

DARK ENERGY
SURVEY

Extra Slides

DARK ENERGY SURVEY

The PreCam Survey: Benefits to DES

1. Early on-sky tests with a "1/32nd scale" DECam.
   a) Hardware, software, and observing experience (see bulleted list of Lessons Learned).

2. DES *grizy* standard stars (*y*-band in particular), supplementing the Stripe 82 standards and Smith et al. Southern *u'g'r'i'z* standards and permitting a much finer time-resolution of extinction measurements during DES operations
   a) DES survey strategy simulations indicate that DES nightly observations will cross a PreCam field about once an hour on average.
   b) These DES observations of PreCam fields reduces the need for additional dedicated standard star observations during the night by the Blanco – ***this can increase DES observing efficiency by up to 10%***, or, in monetary terms, a savings of 10% x $10,000/night x 525 nights = $525,000.
   c) The PreCam sparse grid also provides improved spatial coverage of calibration fields throughout the DES footprint – any part of the DES footprint is that much closer to a calibration field.

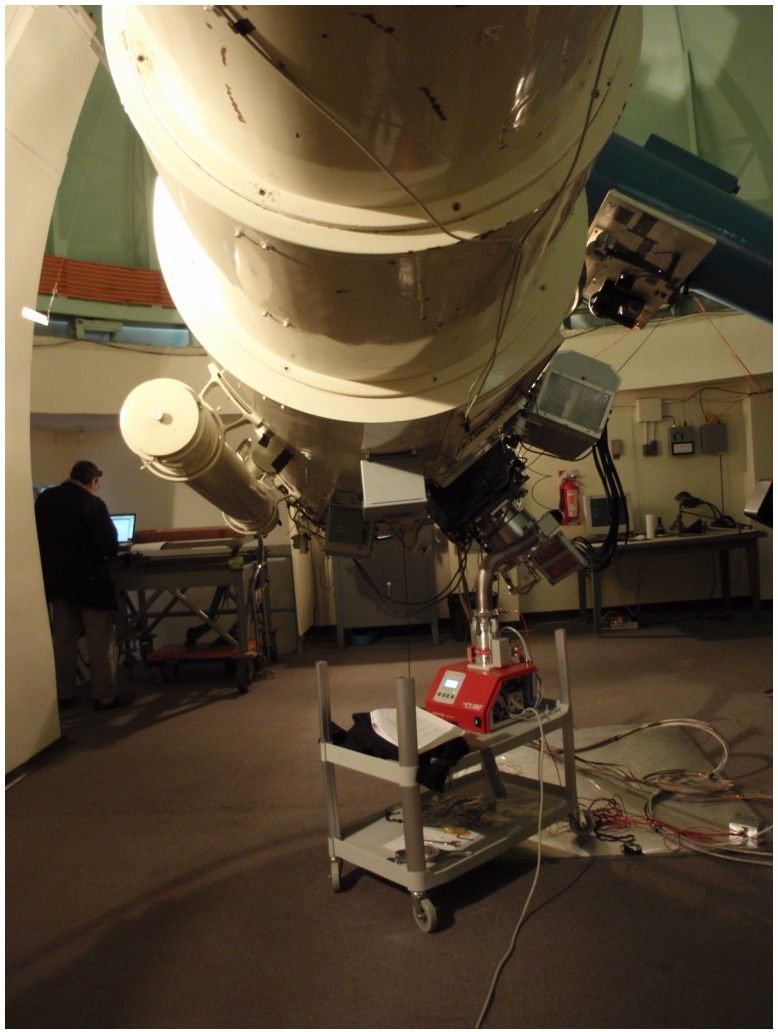
3. Determinations of the transformations between SDSS *griz* and DES *griz* (via observations in SDSS Stripe 82).

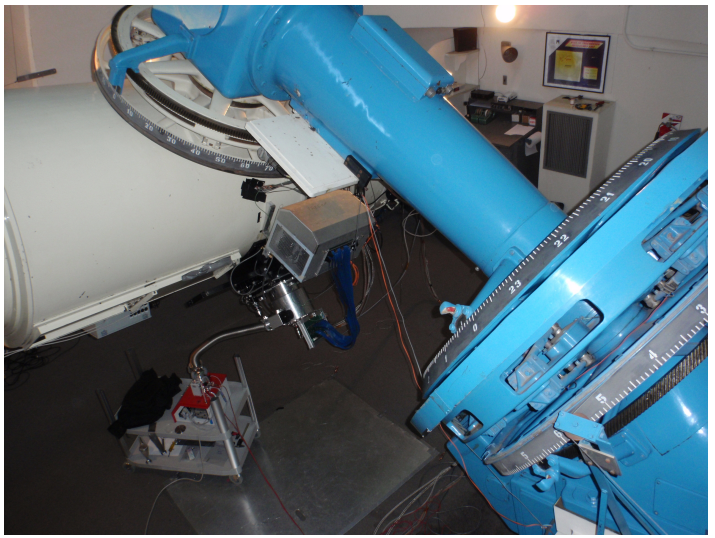
4. Identification of candidate DA white dwarfs (in conjunction with SkyMapper *u*), useful for DES absolute calibrations.

5. Stars that can be used for "quick look" diagnostics of the DES data in during DES operations.

DARK ENERGY SURVEY

PreCam on the Curtis-Schmidt





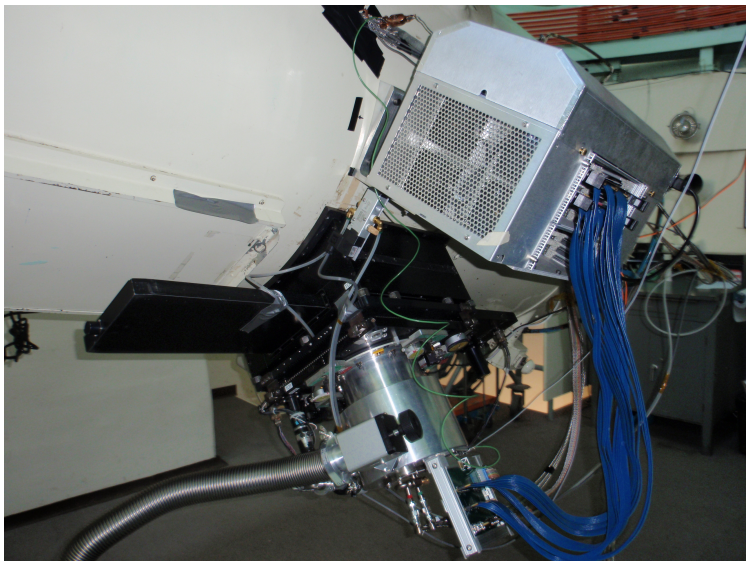
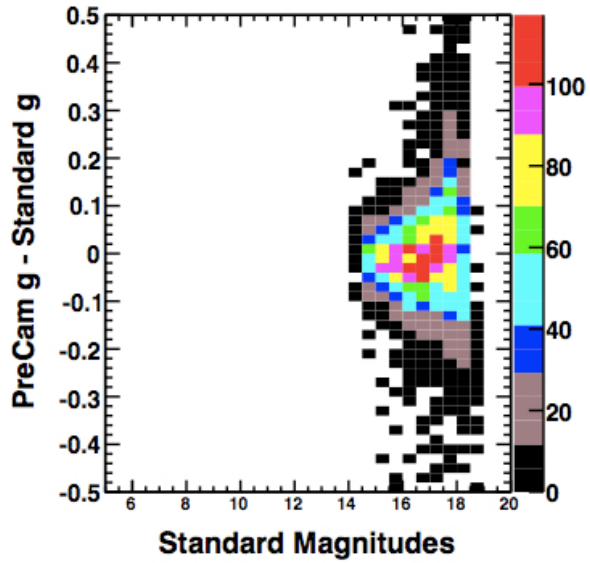


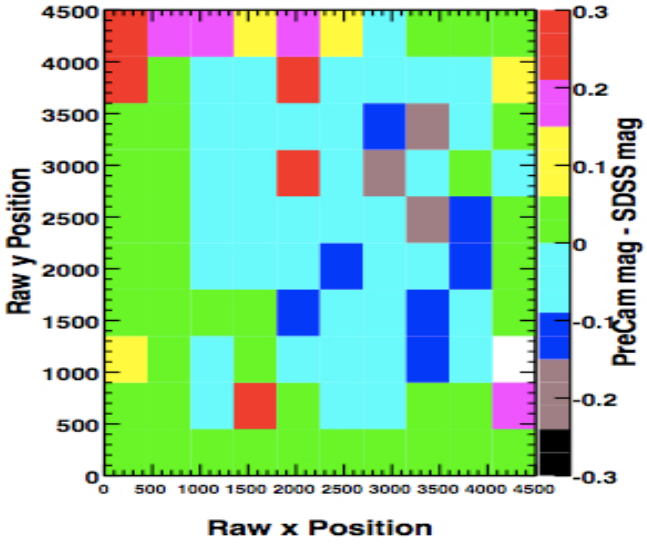
Photo Credits: R. Ogando

Results: Photometry in SDSS Stripe 82

DARK ENERGY SURVEY

- Night of 7 Jan 2011 UT.
- 11 *g*-band images within SDSS Stripe 82.
- Corrections for overall ZPs and for airmass (using site-average first-order extinction coefficients)
- RMS = 9% (mag = 14 - 19).
- No correction for color terms or for variations across focal plane.



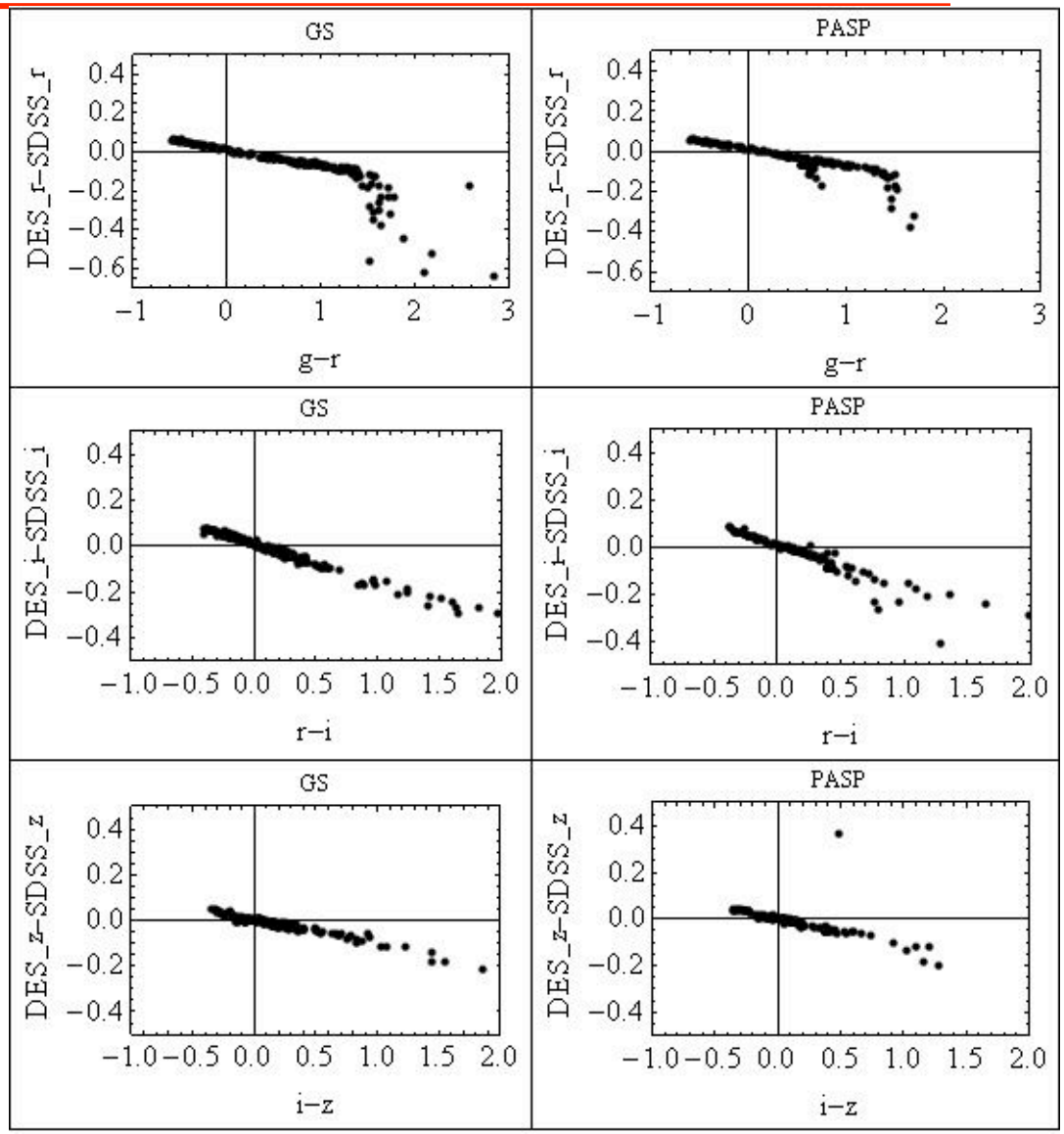


Credit: S. Kuhlmann, H. Spinka

Results: DES-SDSS Color Terms

DARK ENERGY SURVEY

- Synthetic color terms.
- Transmission curves from the PreCam set of 100mm x 100mm DES *grizy* filters.
- Stellar libraries from Gunn-Stryker (GS) and Pickles (PASP).

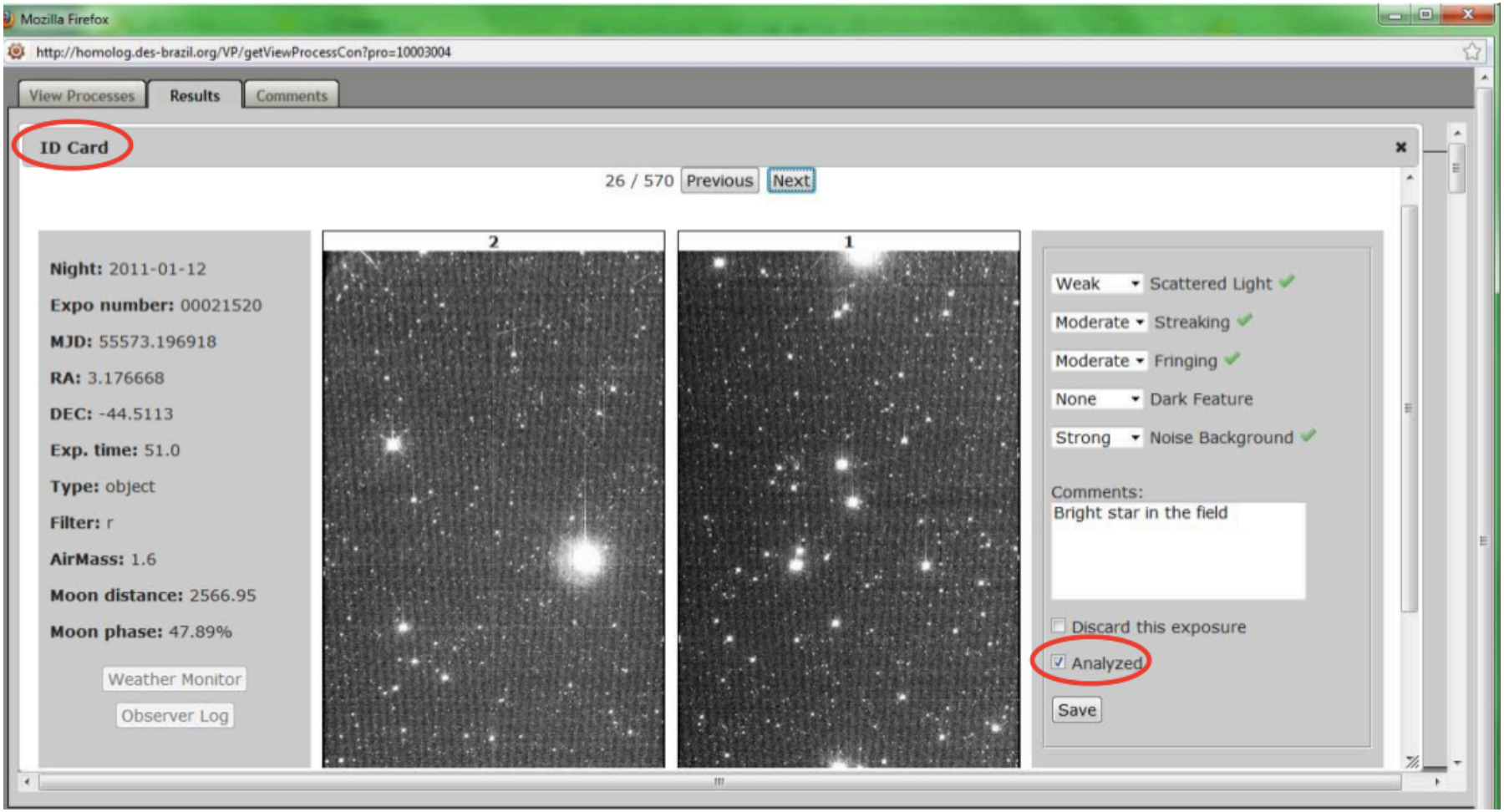


Credit: V. Bragança

Accomplishments/Lessons Learned Relevant to DES Commissioning

DARK ENERGY SURVEY

1. Quick Reduce & DES Portal were tested and substantially improved.



Credit: M. Maia

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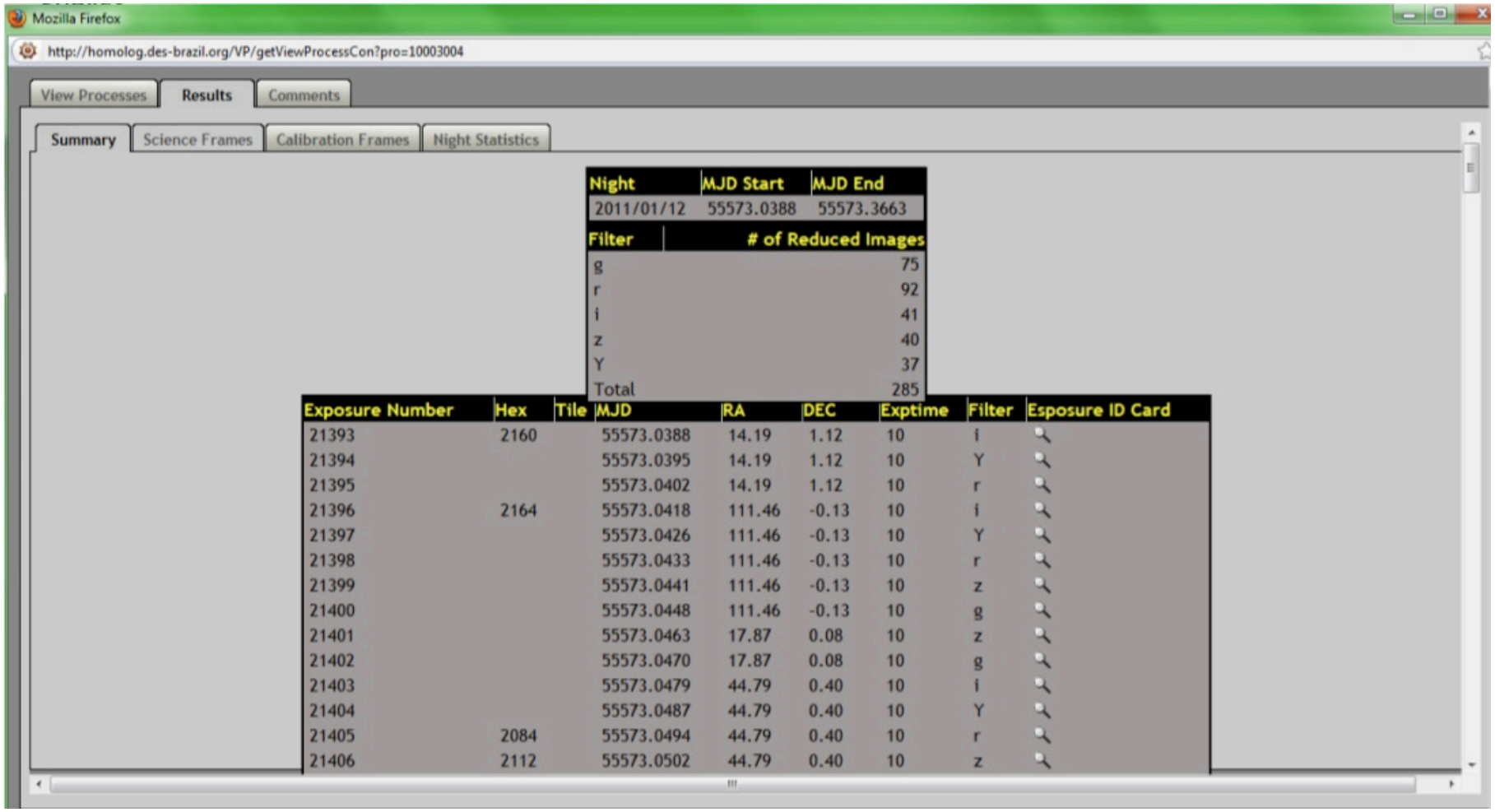


Night	MJD Start	MJD End
2011/01/12	55573.0388	55573.3663

Filter	# of Reduced Images
g	75
r	92
i	41
z	40
Y	37
Total	285

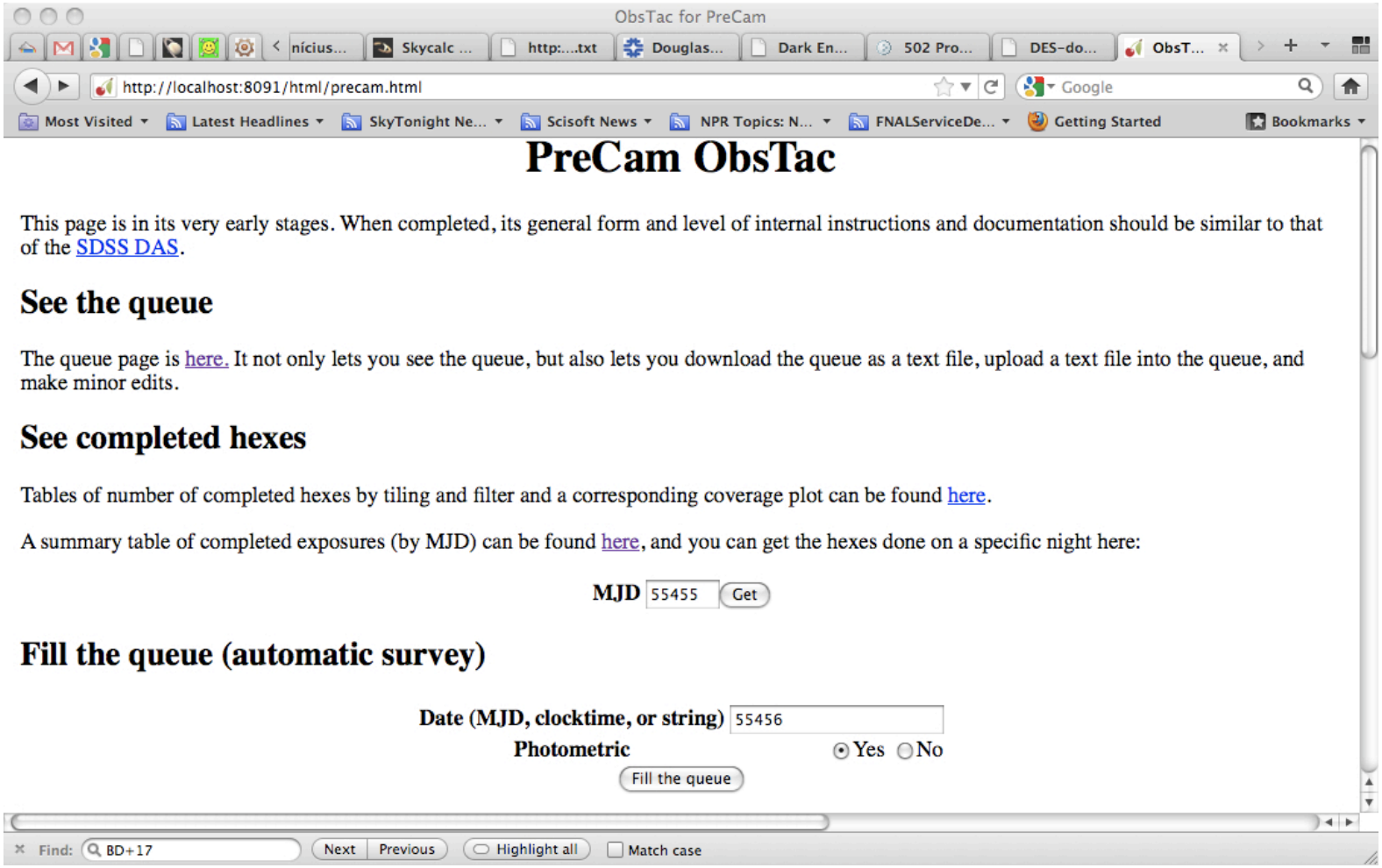
Exposure Number	Hex	Tile	MJD	RA	DEC	Exptime	Filter	Esposure ID Card
21393	2160		55573.0388	14.19	1.12	10	i	
21394			55573.0395	14.19	1.12	10	Y	
21395			55573.0402	14.19	1.12	10	r	
21396	2164		55573.0418	111.46	-0.13	10	i	
21397			55573.0426	111.46	-0.13	10	Y	
21398			55573.0433	111.46	-0.13	10	r	
21399			55573.0441	111.46	-0.13	10	z	
21400			55573.0448	111.46	-0.13	10	g	
21401			55573.0463	17.87	0.08	10	z	
21402			55573.0470	17.87	0.08	10	g	
21403			55573.0479	44.79	0.40	10	i	
21404			55573.0487	44.79	0.40	10	Y	
21405	2084		55573.0494	44.79	0.40	10	r	
21406	2112		55573.0502	44.79	0.40	10	z	

Credit: M. Maia

Accomplishments/Lessons Learned Relevant to DES Commissioning

DARK ENERGY SURVEY

2. ObsTac substantially increased observing efficiency, and its basic design demonstrated its flexibility…

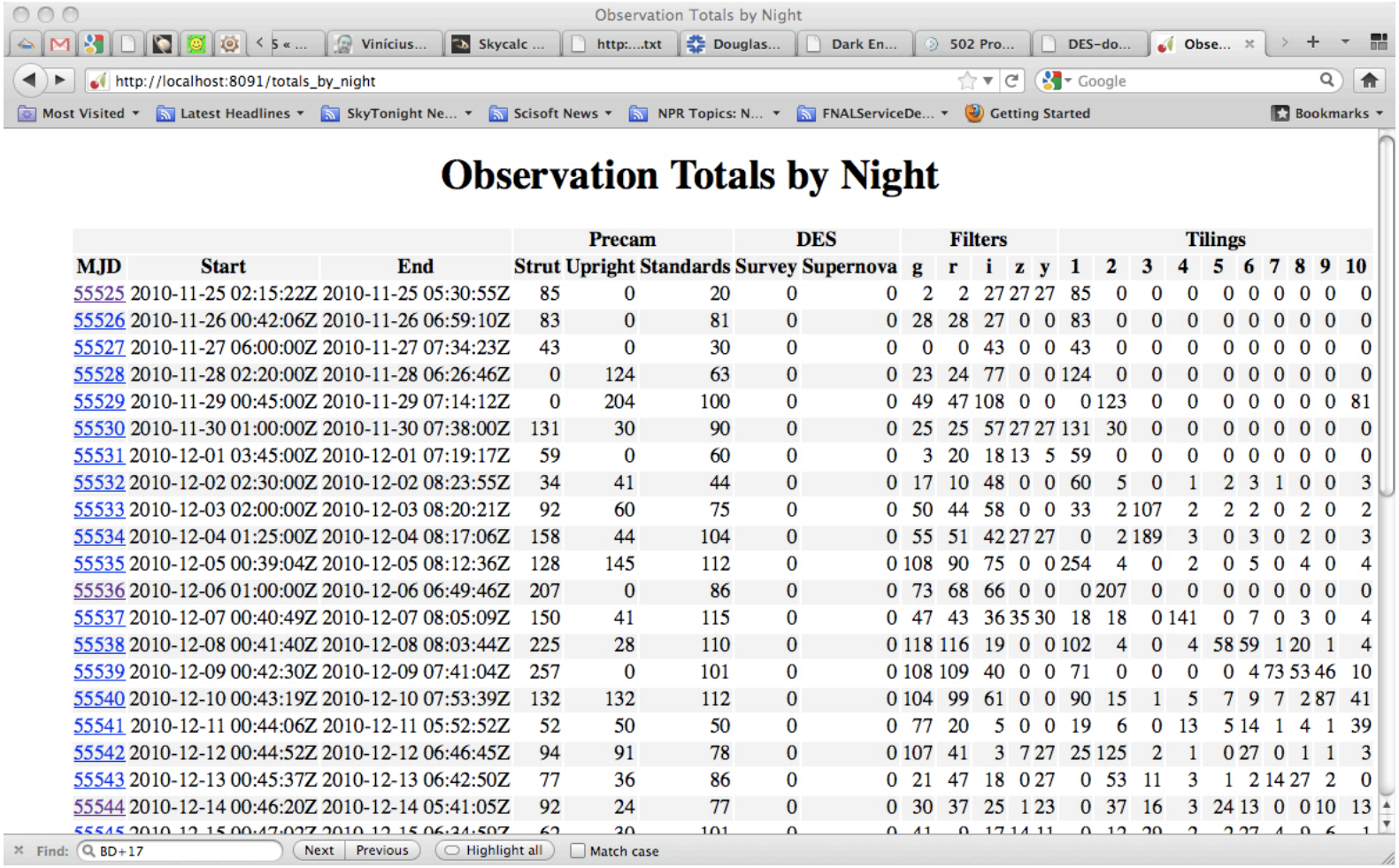


Credit: E. Neilsen

Accomplishments/Lessons Learned Relevant to DES Commissioning

DARK ENERGY SURVEY

2. ObsTac substantially increased observing efficiency, and its basic design demonstrated its flexibility…



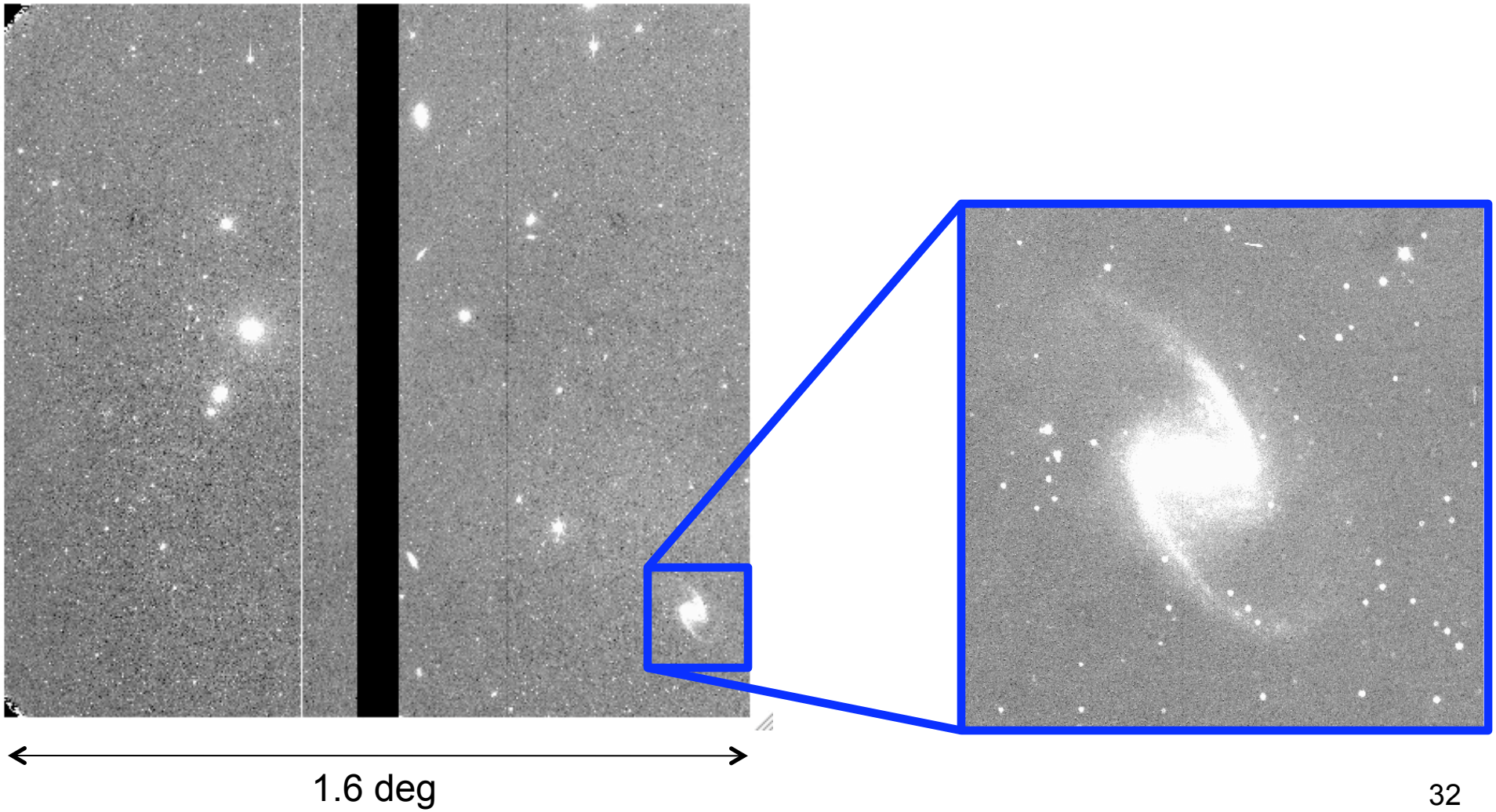
Observation Totals by Night

			Precam			DES		Filters					Tilings									
MJD	Start	End	Strut	Upright	Standards	Survey	Supernova	g	r	i	z	y	1	2	3	4	5	6	7	8	9	10
55525	2010-11-25 02:15:22Z	2010-11-25 05:30:55Z	85	0	20	0	0	2	2	27	27	27	85	0	0	0	0	0	0	0	0	0
55526	2010-11-26 00:42:06Z	2010-11-26 06:59:10Z	83	0	81	0	0	28	28	27	0	0	83	0	0	0	0	0	0	0	0	0
55527	2010-11-27 06:00:00Z	2010-11-27 07:34:23Z	43	0	30	0	0	0	0	43	0	0	43	0	0	0	0	0	0	0	0	0
55528	2010-11-28 02:20:00Z	2010-11-28 06:26:46Z	0	124	63	0	0	23	24	77	0	0	124	0	0	0	0	0	0	0	0	0
55529	2010-11-29 00:45:00Z	2010-11-29 07:14:12Z	0	204	100	0	0	49	47	108	0	0	0	123	0	0	0	0	0	0	0	81
55530	2010-11-30 01:00:00Z	2010-11-30 07:38:00Z	131	30	90	0	0	25	25	57	27	27	131	30	0	0	0	0	0	0	0	0
55531	2010-12-01 03:45:00Z	2010-12-01 07:19:17Z	59	0	60	0	0	3	20	18	13	5	59	0	0	0	0	0	0	0	0	0
55532	2010-12-02 02:30:00Z	2010-12-02 08:23:55Z	34	41	44	0	0	17	10	48	0	0	60	5	0	1	2	3	1	0	0	3
55533	2010-12-03 02:00:00Z	2010-12-03 08:20:21Z	92	60	75	0	0	50	44	58	0	0	33	2	107	2	2	2	0	2	0	2
55534	2010-12-04 01:25:00Z	2010-12-04 08:17:06Z	158	44	104	0	0	55	51	42	27	27	0	2	189	3	0	3	0	2	0	3
55535	2010-12-05 00:39:04Z	2010-12-05 08:12:36Z	128	145	112	0	0	108	90	75	0	0	254	4	0	2	0	5	0	4	0	4
55536	2010-12-06 01:00:00Z	2010-12-06 06:49:46Z	207	0	86	0	0	73	68	66	0	0	0	207	0	0	0	0	0	0	0	0
55537	2010-12-07 00:40:49Z	2010-12-07 08:05:09Z	150	41	115	0	0	47	43	36	35	30	18	18	0	141	0	7	0	3	0	4
55538	2010-12-08 00:41:40Z	2010-12-08 08:03:44Z	225	28	110	0	0	118	116	19	0	0	102	4	0	4	58	59	1	20	1	4
55539	2010-12-09 00:42:30Z	2010-12-09 07:41:04Z	257	0	101	0	0	108	109	40	0	0	71	0	0	0	0	4	73	53	46	10
55540	2010-12-10 00:43:19Z	2010-12-10 07:53:39Z	132	132	112	0	0	104	99	61	0	0	90	15	1	5	7	9	7	2	87	41
55541	2010-12-11 00:44:06Z	2010-12-11 05:52:52Z	52	50	50	0	0	77	20	5	0	0	19	6	0	13	5	14	1	4	1	39
55542	2010-12-12 00:44:52Z	2010-12-12 06:46:45Z	94	91	78	0	0	107	41	3	7	27	25	125	2	1	0	27	0	1	1	3
55543	2010-12-13 00:45:37Z	2010-12-13 06:42:50Z	77	36	86	0	0	21	47	18	0	27	0	53	11	3	1	2	14	27	2	0
55544	2010-12-14 00:46:20Z	2010-12-14 05:41:05Z	92	24	77	0	0	30	37	25	1	23	0	37	16	3	24	13	0	0	10	13

Credit: E. Neilsen

A Processed *i*-band PreCam Image from Jan 13

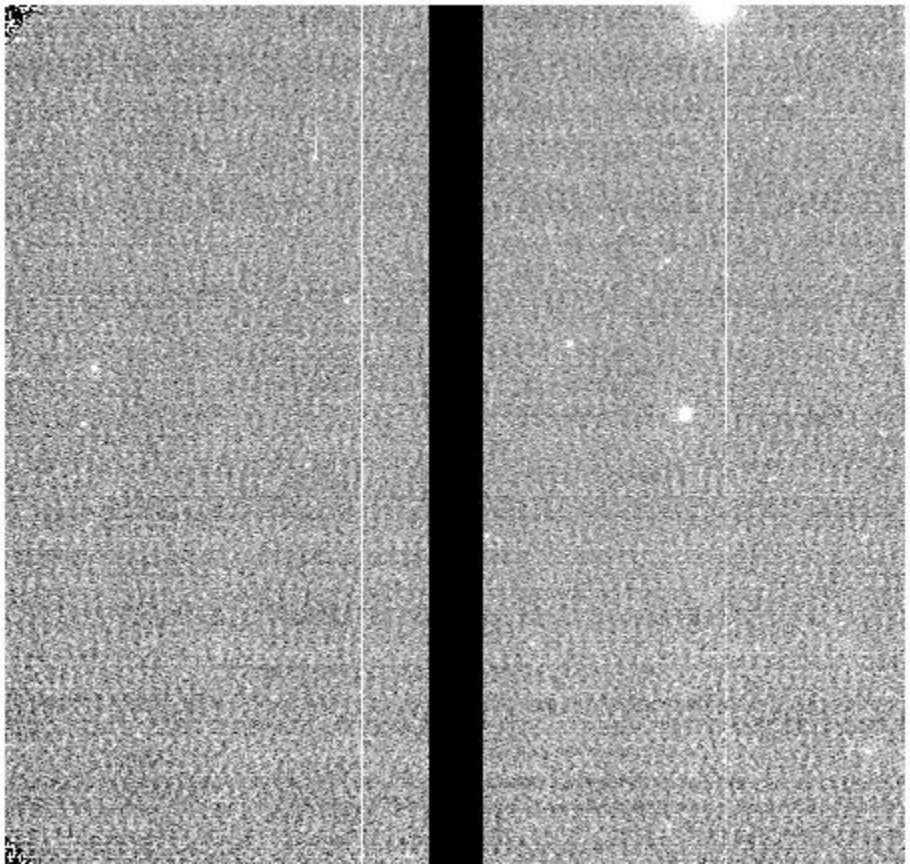
DARK ENERGY SURVEY



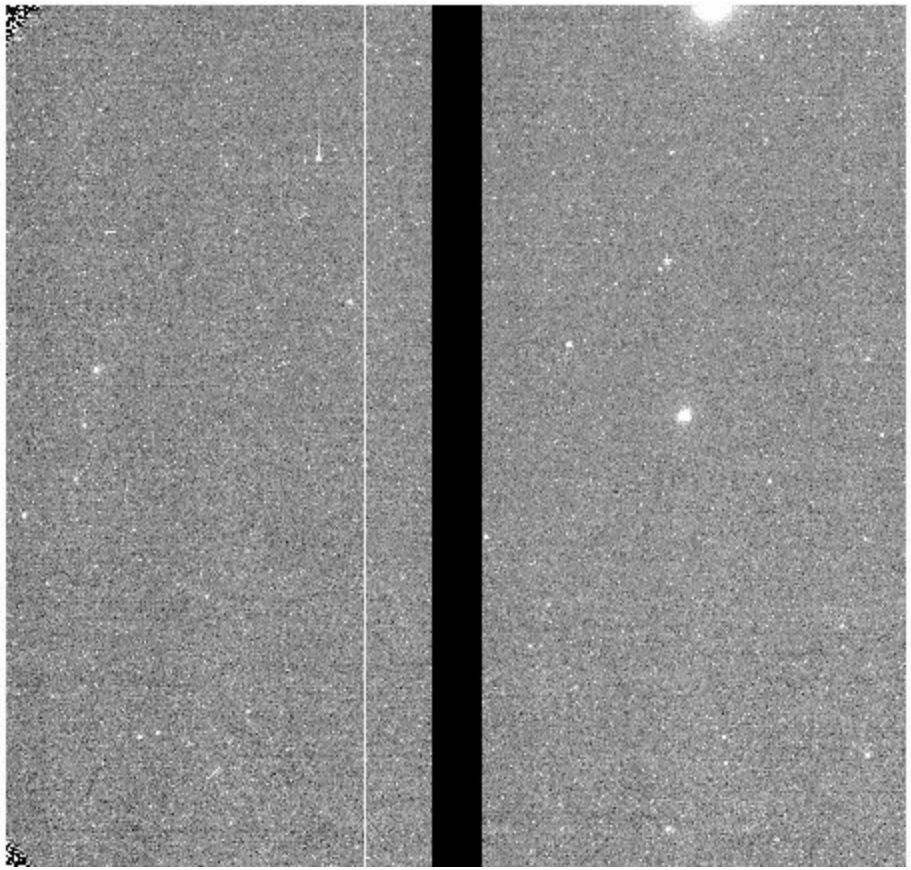
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After

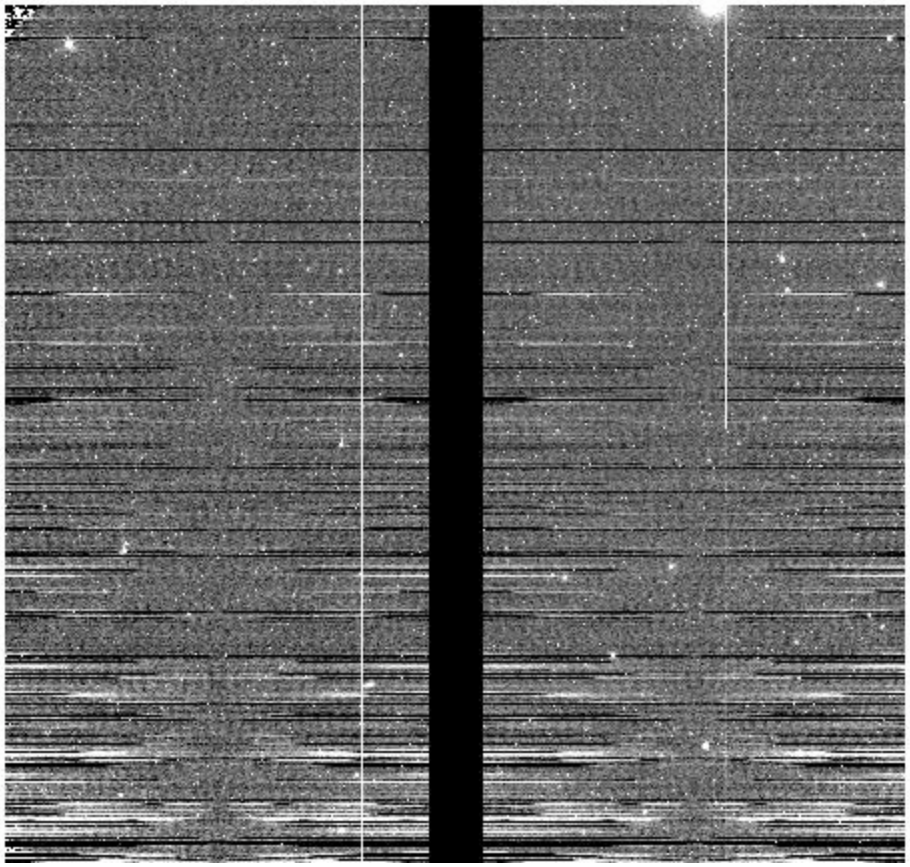


Credit: S. Allam

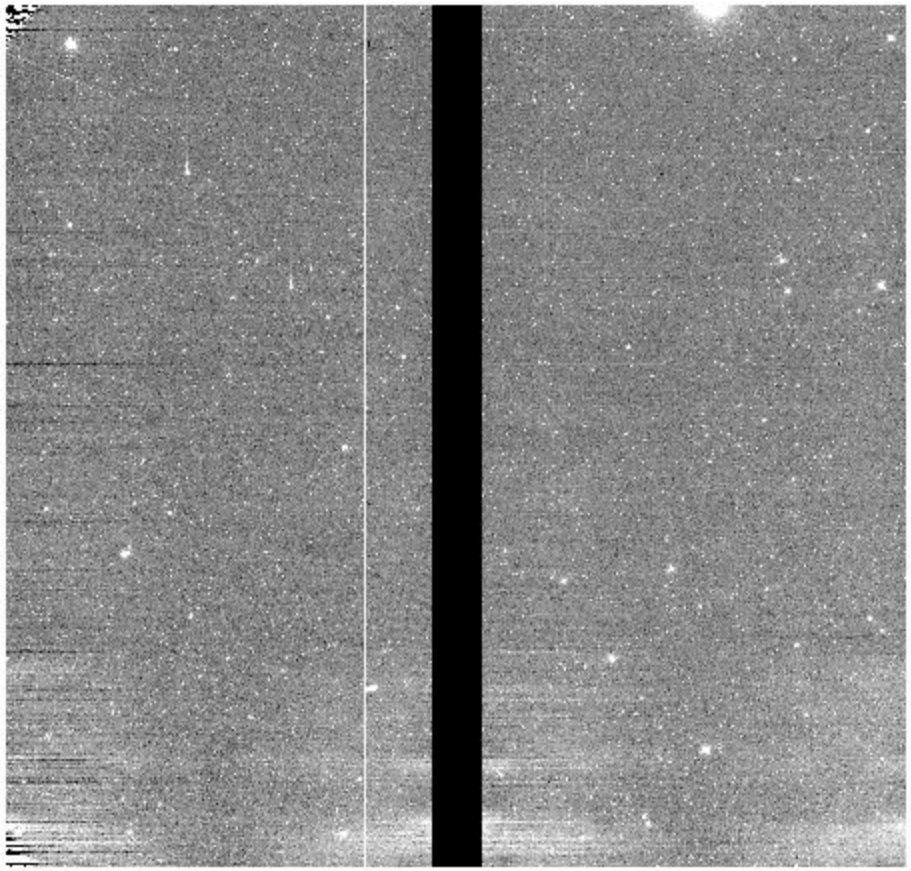
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After

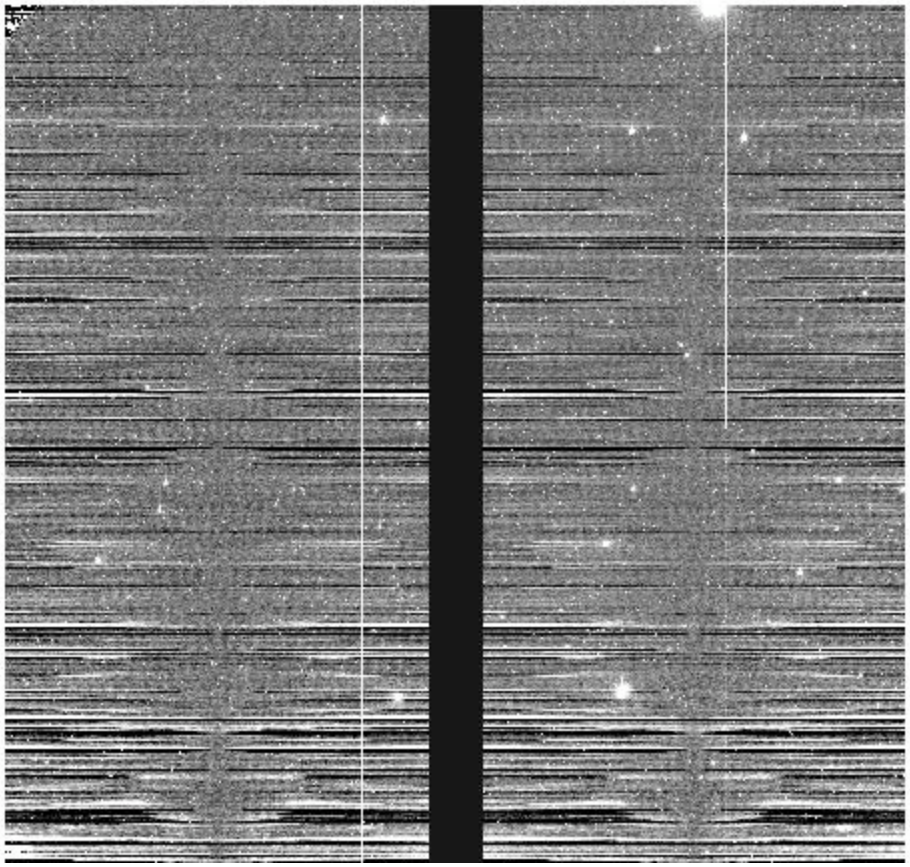


Credit: S. Allam

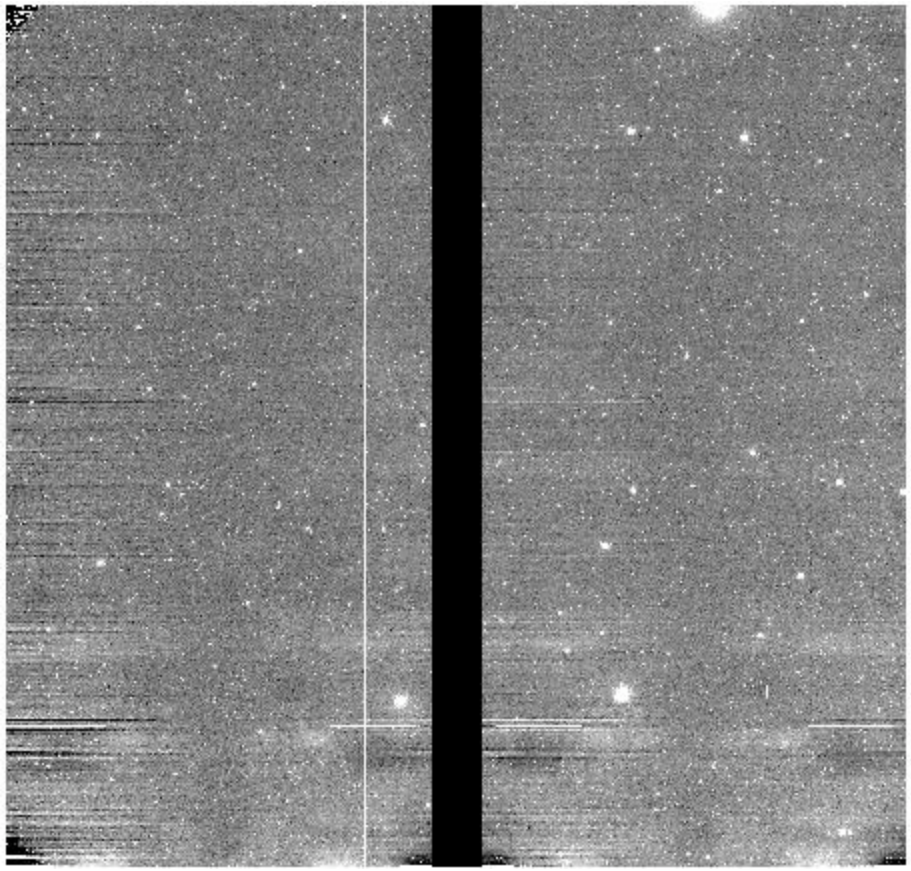
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After

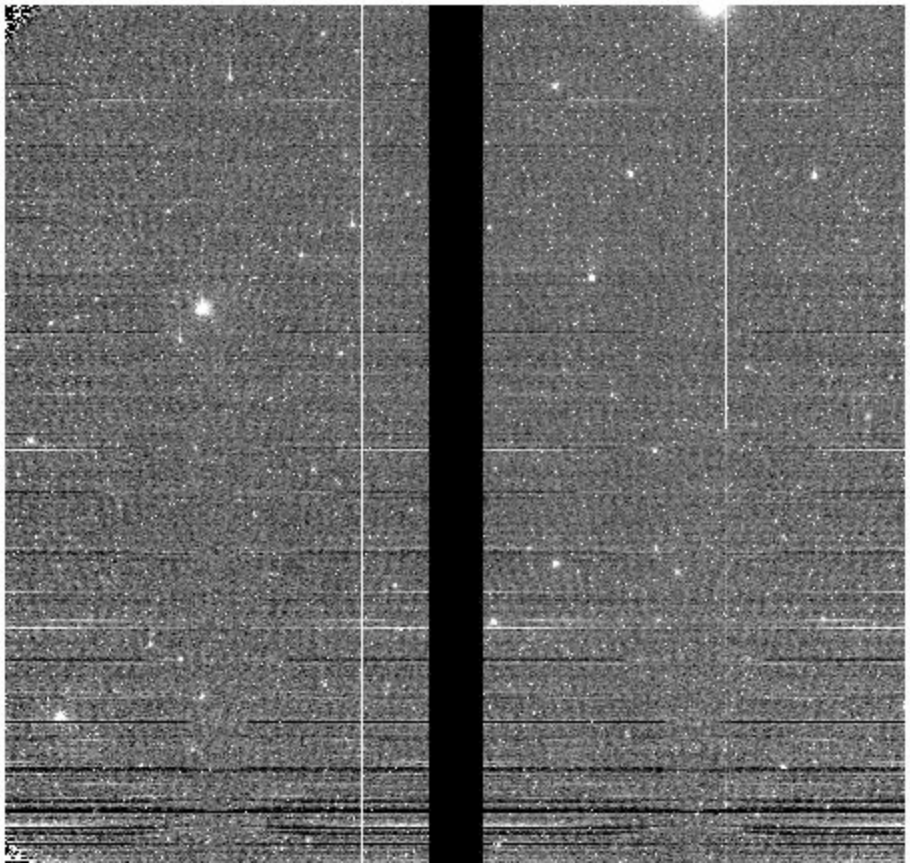


Credit: S. Allam

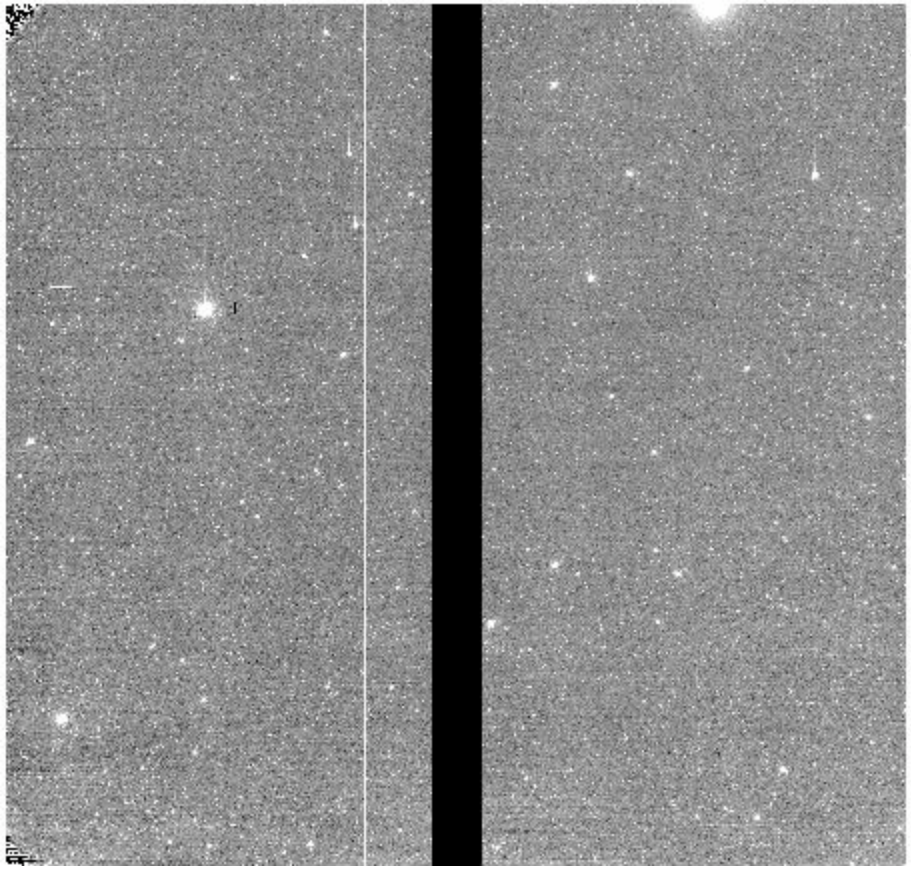
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After

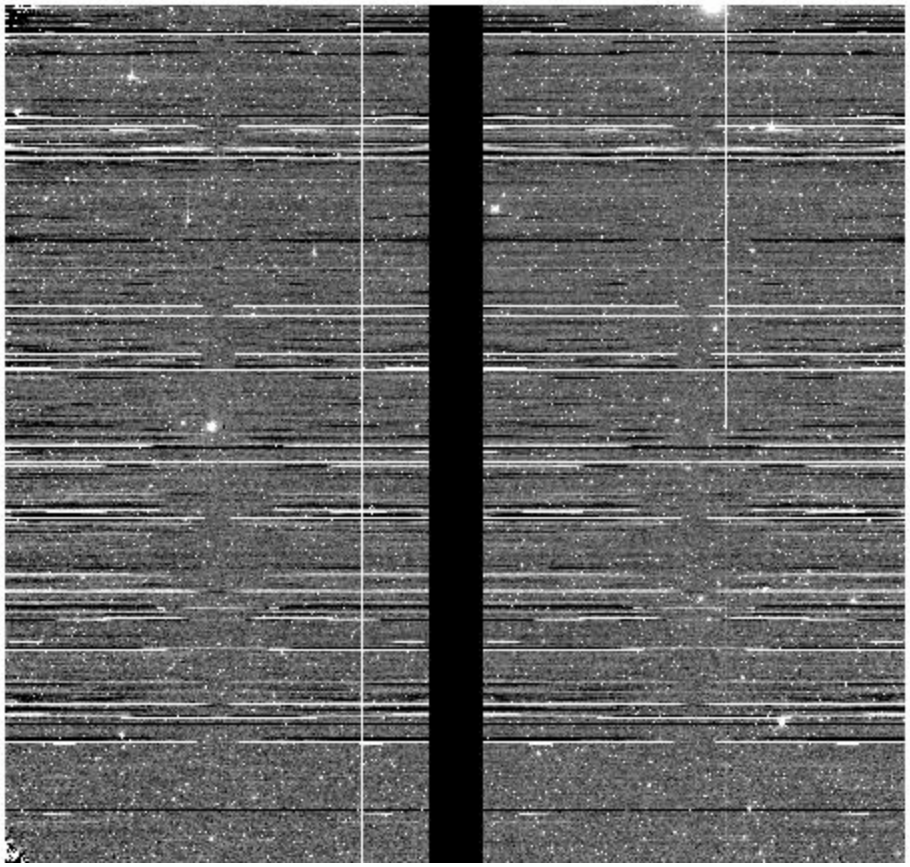


Credit: S. Allam

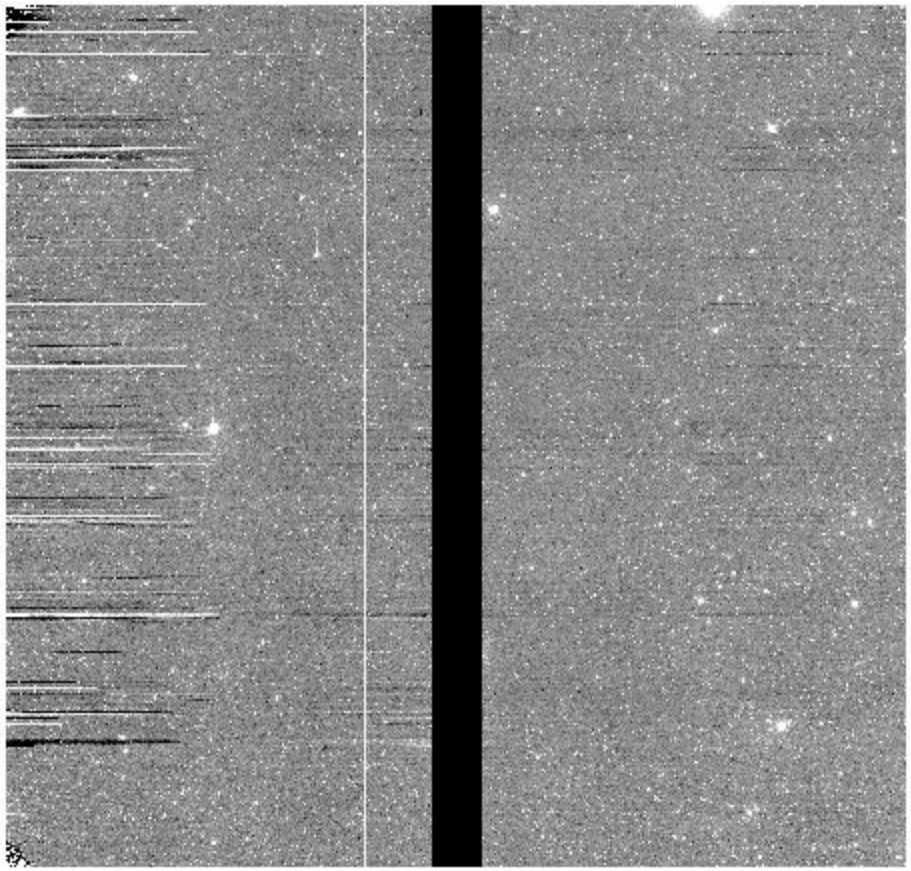
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After

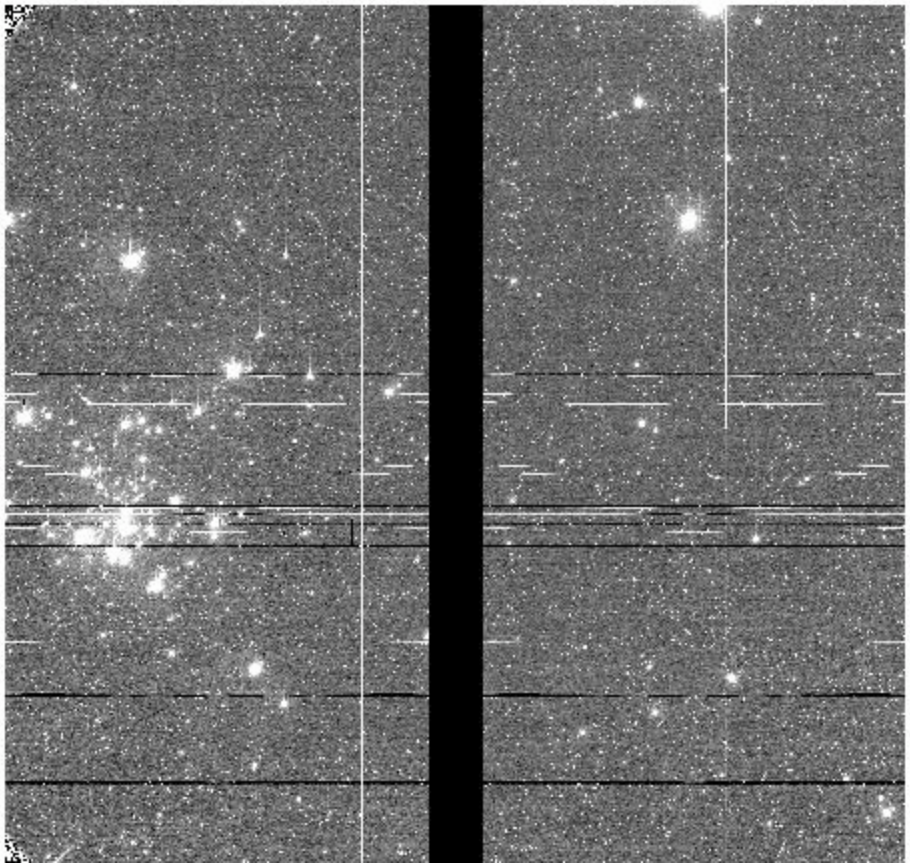


Credit: S. Allam

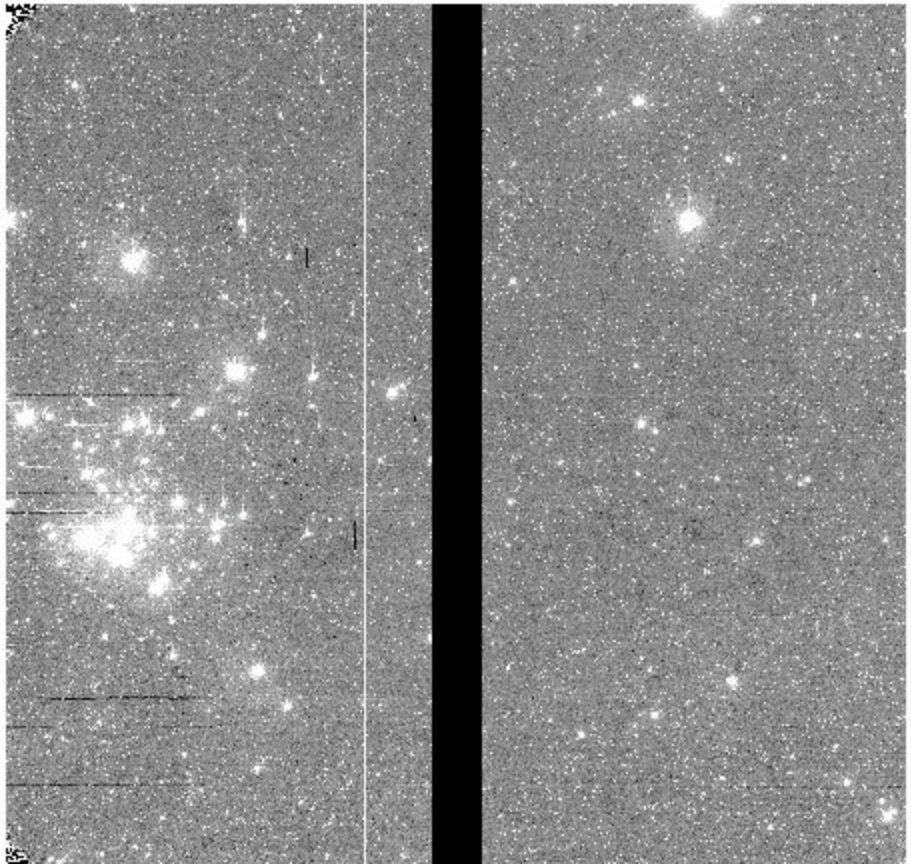
DARK ENERGY SURVEY

More Examples: Before and After Horizontal Streaking Correction

Before



After



Credit: S. Allam